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| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on application enablement for satellite access enabled 5G services;  (Release 19) | |
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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document is a technical report capturing the study on application enablement for Satellite access enabled 5G Services over 3GPP networks. The aspects of the study include identifying architecture requirements, supporting architecture for satellite access enabled 3GPP services and application enablers (either by defining new functional model or by enhancing existing functional model), and corresponding solutions.

The study is based on the requirements as defined in 3GPP TS 22.261 [2] and related use cases (for e.g. in 3GPP TR 22.822 [3] and 3GPP TR 22.865 [4]). The study is dependent on 3GPP TS 23.501 [5] (5GC architecture for satellite access for NR), 3GPP TS 23.502 [6] (procedures for NR satellite access), 3GPP TS 23.503 [7] (PCF for Satellite backhaul), 3GPP TS 23.401 [8] (EPC architecture for satellite access for IoT), 3GPP TS 23.682 [9] (EPC architecture enhancements to facilitate communications with packet data networks and applications).

# 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; Stage 1".

[3] 3GPP TR 22.822: "Study on using satellite access in 5G; Stage 1".

[4] 3GPP TR 22.865: "Study on satellite access - Phase 3".

[5] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[6] 3GPP TS 23.502: "Procedures for the 5G system, Stage 2".

[7] 3GPP TS 23.503: "Policy and Charging Control Framework for the 5G System".

[8] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[9] 3GPP TS 23.682: "Architecture enhancements to facilitate communications with packet data networks and applications"

[10] 3GPP TS 23.558: "Architecture for enabling Edge Applications"

[11] 3GPP TS 22.179: "Mission Critical Push to Talk (MCPTT); Stage 1"

[12] 3GPP TR 38.821: "Solutions for NR to support Non-Terrestrial Networks (NTN)"

[13] 3GPP TR38.811: "Study on New Radio (NR) to support non-terrestrial networks"

[14] 3GPP TS 23.554: "Application architecture for MSGin5G Service"

[15] 3GPP TR 23.700-29: "Study on integration of satellite components in the 5G architecture;"

[16] R2-2107453: "On LEO satellite flyover timing and discontinuous coverage", 3GPP TSG-RAN WG2 Meeting #115-e, August 9th - 27th, 2021

[17] R2-2206115: "ASN.1 proposal for satellite assistance information for prediction of discontinuous coverage", 3GPP TSG-RAN WG2 Meeting #118-e, May 9th – May 20th, 2022

[18] 3GPP TS 23.280: "Common functional architecture to support mission critical services; Stage 2"

[19] 3GPP TS 23.289: "Mission Critical services over 5G System; Stage 2"

[20] 3GPP TS 23.436: "Functional architecture and information flows for Application Data Analytics Enablement Service".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

5GC 5G Core Network

5QI 5G QoS Identifier

AC Application Client

ACR Application Context Relocation

AF Application Function

AMF Access & Mobility Management Function

ARP Allocation and Retention Priority

AS Application Server

CN Core Network

DL Down-Link

DNAI Data Network Access Identifier

EAS Edge Application Server

ECSP Edge Computing Service Provider

EDGEAPP Edge Application

EDN Edge Data Network

EEC Edge Enabler Client

EES Edge Enabler Server

eNB Evolved Node B

EPC Evolved Packet Core

FQDN Fully Qualified Domain Name

GBR Guaranteed Bit Rate

GEO Geostationary Earth Orbit

gNB 5G Node B

GW Gateway

ID Identity

IMS IP Multimedia Subsystem

IoT Internet of Things

IP Internet Protocol

ISL Inter-Satellite Link

KPI Key Performance Indicators

LEO Low-Earth Orbit

MC Mission Critical

MCPTT Mission Critical Push-to-Talk

MEO Medium Earth Orbit

MME Mobility Management Entity

NEF Network Exposure Function

NGSO Non-Geostationary Satellite Orbit

NTN Non-Terrestrial Network

NR New Radio

PCF Policy Control Function

PGW Packet Gateway

PGW-U Packet Gateway Userplane

QoS Quality of Service

RAN Radio Access Network

RAT Radio Access Type

S&F Store and Forward

SCAI Satellite Coverage Availability Information

SCEF Service Capability Exposure Function

SEAL Service Enabler Architecture Layer

SGP4 Simplified General Perturbation 4

SIB System Information Block

SMF Session Management Function

SMS Short Message Service

TLE Two Line Elements

TN Terrestrial Network

UAV Uncrewed Aerial Vehicle

UE User Equipment

UL Up-Link

UPF User Plane Function

URI Uniform Resource Identifier

V2X Vehicle-to-Everything

VAL Vertical Application Layer

# 4 Key issues

## 4.1 Key issue #1: Usage of satellite access characteristics for the application enablement

### 4.1.1 Description

3GPP SA1 has specified the service requirements for 5G for satellite access in 3GPP TS 22.261[2] which including supporting 5G system with satellite access, suitable QoS parameters for traffic over a satellite backhaul, etc. And 3GPP SA2 has also specified the architecture and solutions in Rel-17 and Rel-18 to support these services requirements identified in SA1.

Service enablers defined by SA6 should also considering to take advantage of the output from SA1 and SA2 to ensure that application enablers support the satellite access, and should utilize the satellite access characteristics (e.g. QoS parameters for traffic over a satellite access) to optimise application layer enablement behaviour to provide a better service experience. Also investigate the need of any new analytics related to satellite access characteristics that need to be supported as part of the ADAE service (3GPP TS 23.436 [20]) which can be utilized by the application servers and application enablement layers in order to provide a better service experience over satellite access.

### 4.1.2 Open issues

To support the satellite access in application enablers, the following aspects need to be studied:

- What are the satellite access characteristics that can be utilized by the application enablers?

- Whether and how to use the satellite access characteristics (e.g., QoS parameters for traffic over a satellite access) to optimise the application enablement behaviour for the existing application enablers.

- Whether and what new analytics required for the satellite access for providing a better service experience by the existing application enablement servers or application servers.

## 4.2 Key issue #2: Edge computing on satellite

### 4.2.1 Description

UPF and Edge in the backhaul part of a 5GS (i.e. on board a GEO satellite) facilitates reduction of latency and faster service provisioning to end users. 3GPP TS 23.558 [10] (SA6) defines Architectures for enabling Edge applications including the procedures for EAS discovery. Although 3GPP TS 23.558 [10] specification is created to cover the most generic EDGEAPP cases– it would be beneficial to study whether the placement of Edge on board satellite requires some enhancements of application enablers. The motivation for this is to explore whether EDGEAPP enhancements could reduce latency in cases when Edge has been placed on board GEO satellite. Besides, the interest is to investigate whether EDGEAPP enhancements could reduce data load in the feeder link (the link between 5GC on the ground and GEO satellites).

NOTE: The focus of this Key Issue is limited to aspects of EDGEAPP in 3GPP TS23.558 [10].

### 4.2.2 Open issues

Deployment of Edge computing on board GEO satellites might impact the latency of application control and data information exchange. To assess the impacts of using Edge on board GEO satellites it would be benefitial to study the following aspects with the aim to reduce latency and data exchange over satellite feeder link:

1) Investigate different deployment options for EDGEAPP when EASs are deployed on board GEO satellites?

2) When/how could EAS discovery by the EEC in EDGEAPP be optimized?

3) Whether and how the service continuity procedures are impacted while the UE is only connected with NTN?

## 4.3 Key issue #3: Satellite access with discontinuous coverage

### 4.3.1 Description

In a network with satellite access, a UE may experience a situation of discontinuous coverage, due to e.g., a sparse NGSO satellite constellation deployment. An illustration of a discontinuous coverage pattern for a given UE location and a single example LEO satellite at a nominal 600 km altitude is represented in Figure 4.3.2-1 (reproduced from [R2-2107453](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_115-e/Docs/R2-2107453.zip) [16]). The figure shows the flyovers where the satellite passes above 30 degrees elevation as seen from the UE location. The rise time of the satellite is plotted on the x axis against the visibility duration on the y axis. The results do not consider link budget aspects, only geometrical visibility above the given elevation angle. In the provided example, the satellite is visible from the UE location twice on most days, and occasionally three times, and the interval between passes varies between ~9 to 13.3 hours, with a mean of 11.9 hours. The median duration of the visibility window lasts around 220 seconds (3.6 minutes), with 90% of flyovers longer than 110 seconds.

This sort of discontinuous coverage pattern between the UE and a satellite can be predicted ahead of time for periods of days or even a few weeks with good accuracy (e.g. time errors of a few tens of seconds in estimating the starting time of the satellite pass when considering prediction windows of up to a few tens of days) by means of orbit propagation models and satellite ephemeris information (see [R2-2206115](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_118-e/Docs/R2-2206115.zip) [17] for prediction estimation errors using TLE and SGP4 propagator).



Figure 4.3.1-1: Flyovers and duration of visibility (≥ 30 degrees elevation) for a single LEO-600 km satellite (source: [R2-2107453](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_115-e/Docs/R2-2107453.zip) [16])

From a network perspective, support to cope with the discontinuous coverage nature of the service link in sparse constellations has been specified in Rel-17 and Rel-18. This support includes optional enhancements within the radio access network (e.g., satellite ephemeris parameters are broadcast in SIBs for satellite pass predictions for IoT NTN access) and within the core network (e.g., mobility management and power saving optimization, coverage availability information provisioning, paging, overload control). Coverage availability information provisioning to the UE and to the MME/AF entities have been also been identified, though no specific protocol or format have been defined in the specifications. All these enhancements help the UE and the network to gracefully operate under a discontinuous coverage pattern.

However, regardless of these enhancements at the network level, the discontinuous coverage nature of the service link results into an intermittent connectivity pattern between the UE and the Application Server (AS)/Application Function (AF) that has also a direct impact on the behaviour of the application.

Supplying information on the discontinuous coverage pattern or related services to the application layer will help applications to design themselves for handling discontinuity accordingly. For instance, if the discontinuous /intermittent connectivity pattern can be predicted in advance and exposed to the application layer in the network side, the application layer could use this information to properly schedule data transfers between the UE and the AS/AF (e.g. some information flows can be given precedence during short connectivity intervals, bulky data exchanges can be deferred and planned during longer connectivity intervals, notifications on expected data delivery times can be provided, etc.).

Once the discontinuous coverage patterns provided by different satellite operators are retrieved by an application enabler on the network side, specific information exposure policies can be enforced. For example, a certain vertical application may be allowed to access such discontinuous coverage patterns in specific times of the day and under specific circumstances, for example when the UE is located in a certain geographical area.

It is therefore necessary to study if some support to handle discontinuous coverage at application layer should be introduced in existing or a new application enabler.

### 4.3.2 Open issues

To support the discontinuous satellite coverage in application enabler, the following aspects need to be studied:

- Whether and how the information on discontinuous satellite coverage needs to be exposed to the application layer (e.g. semantics, service-based interfaces, etc.) on the AS/AF side.

- Whether and how the application enabler enforces policies (e.g., based on the time of the day, the UE location, etc.) on the discontinuous coverage information exposure towards the vertical applications.

## 4.4 Key issue #4: Satellite access support for MC services

### 4.4.1 Description

To ensure reliable MC services with larger coverage area, MC systems can benefit from satellite access, especially when the connectivity provided by the terrestrial networks faces limitations, e.g., bad coverage at remote areas. Hence, MC service UEs can be able to connect to MC system via satellite access to ensure service continuity.

There are different satellite systems, based on altitude, roundtrip time and coverage such as; Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary Equatorial Orbit (GEO). Among these different systems, LEO offers low latency, and large area capacity density.

In this study, it is worth understanding the deployment scenarios to utilize satellite access for MC services, and understanding how the MC KPIs (e.g., latency requirement) can be met when MC service users are connecting to the MC system via satellite access.

Location reporting aspects for MC service clients is to be considered and understand whether location reports provided by MC service users over satellite access may or may not be different from MC service users over terrestrial access.

### 4.4.2 Open issues

There are several aspects that need to be considered and studied to support satellite access for MC services, including but not limited to:

1. Identify the different deployment scenarios for MC services using satellite access to result in a better MC service user experience.

## 4.5 Key issue #5: Edge on board NGSO Satellite

### 4.5.1 Description

NGSO satellites are satellites moving with respect to the earth surface and they can be deployed in MEO (8,000 km – 20,000 km ) or LEO (400 km – 2000 km) orbits. This will reduce the one way latency. To utilize these reduced latencies UPFs as well as gNBs can be deployed on the NGSO.

### 4.5.2 Open issues

This key issue studies how to deploy EAS(s) and EES(s) on NGSO satellite and whether and how the corresponding discovery, service provisioning and service continuity are impacted.​

- How the EES(s) are placed on board the Satellite.

- How the EAS(s) are placed on board the Satellite.

- Whether and how the discovery and the service provisioning are impacted.​

- Whether and how the service continuity procedures are impacted while the UE is only connected with NTN.

- Whether and how the EAS can be relocated while the UE can be connected with NTN/TN.

## 4.6 Key issue #6: Support of UE-Satellite-UE communication for IMS services via Satellite access

### 4.6.1 Description

It has been described in the 3GPP TS 22.261 [6] that a 5G system with satellite access shall support UE-Satellite-UE communication regardless of whether the feeder link is available or not, and 5G system also be able to support different types of UE-Satellite-UE communication (e.g. voice, messaging, broadband, unicast, multicast, broadcast).

According to 3GPP TR 23.700-29 [15], the UE-satellite-UE communication refers to the communication between UEs under the coverage of one or more serving satellites without the user plane traffic going through the ground network.

The serving satellites may be the different types (e.g. LEO, MEO, and GEO) and the feeder link may be direct from the serving satellite to a ground gateway or through ISL (Inter-Satellite Link) to another satellite with a link to a ground gateway, etc.

Figure 4.6.1-1 is the example of scenarios for UEs-satellite-UEs communications for IMS services over LEO constellations without ISL.



Figure 4.6.1-1: An example of UEs-SAT-UEs communication on LEO satellite without ISL

In this study, it is worth understanding the deployment scenarios to utilize satellite access and the procedure and function impacts on the application enabler for the IMS services.

### 4.6.2 Open issues

From the application enabler’s perspective, the key issue will focus on how to support the IMS service via satellite access in the application enabled layer, it is proposed to study the following items:

- Investigate different deployment options for the application enabler of IMS (i.e. eMMTEL App) to utilize satellite access.

## 4.7 Key issue #7: Usage of S&F events information for the application enablement

### 4.7.1 Description

3GPP SA1 has specified the service requirements for 5G for satellite access in 3GPP TS 22.261 [22.261] as following which includes supporting Store and Forward (S&F) Satellite Operation. And 3GPP SA2 is studying the exposure of S&F events information to support these services requirements identified in SA1.

- Subject to operator’s policies, a 5G system with satellite access supporting S&F Satellite operation shall be able to allow the operator or a trusted 3rd party to apply, on a per UE and/or satellite basis, an S&F data retention period.

- Subject to operator’s policies, a 5G system with satellite access supporting S&F Satellite operation shall be able to allow the operator or a trusted 3rd party to apply, on a per UE and/or satellite basis, an S&F data storage quota.

- A 5G system with satellite access shall be able to inform an authorised 3rd party whether S&F Satellite operation is applied for communication with a UE and to provide related information (e.g. estimated delivery time to the authorised UE).

SA2 is studying the following S&F events information:

- Registration in S&F Mode

- Feeder Link Available

- Expected Delivery/Delay Time

Editor's note: S&F events information is dependent on SA2.

Services and application enablers defined by SA6 should also consider to take advantage of the output from SA1 and SA2 related to utilizing the S&F events information. When a UE registers to the network in S&F mode and is available to send/receive data on specific occasions only (e.g. when satellites fly-over and later connect to ground station), AF can leverage S&F events information. For e.g. if the UE is registered in S&F mode, the AF may want to adjust the frequency, size of data, message acknowledgement handling, ack timers etc. Another e.g. is AF can schedule delivery based on Feeder-Link availability etc.

Hence, it is desirable to study impacts to application enablers, while supporting S&F Satellite operation and S&F events information is shared to the AF.

### 4.7.2 Open issues

To support utilization of S&F events information by application enablers, the following aspects need to be studied:

- What are the S&F events information that can be utilized by the application enablers?

- How to use the S&F events information to optimise the application enablement behaviour?

- Whether and how the S&F Satellite operation information can be exposed to the 3rd party/VAL server.

## 4.8 Key issue #8: Impact of satellite access on KPIs for Mission Critical group communications

### 4.8.1 Description

Satellite access may be valuable for Mission Critical communication, especially in remote areas and during disaster relief scenarios. Participants connected via satellite access may be crucial in Mission Critical group communications. Still, it should be considered that it is likely that Mission Critical group communication KPIs may be impacted for all participants if one participant is connected via Satellite access. KPIs outside the normal range can have a strong negative operational impact. Participants of MCX group communications may be confused by an unexpected drop in KPIs due to a participant being connected via Satellite access.

Hence, it is desirable to study the impact of satellite access to Mission Critical KPIs and how to mediate possible operational consequences.

### 4.8.2 Open issues

The following aspects need to be studied:

- What is the actual impact of satellite access to the KPIs for Mission Critical communication?

- Whether and how participants of group communications can be informed about reduced KPIs due to one or more participants being connected via satellite.

# 5 Architecture requirements

## 5.1 General architecture requirements

[AR-5.1-a] The architecture shall support deployment of application enablers and services over satellite connectivity.

## 5.2 Mission Critical service architecture requirements

[AR-5.2-a] The architecture shall support deployments to obtain MC services over satellite connectivity.

## 5.3 EDGEAPP architecture requirements

[AR-5.3-a] The EDGEAPP shall support satellite connectivity enabled with deployment of EDGEAPP architecture components onboard satellite.

[AR-5.3-b] The EDGEAPP shall support satellite connectivity enabled with multiple deployment options of EDGEAPP architecture components onboard satellite.

[AR-5.3-c] The EDGEAPP shall support satellite connectivity enabled with EAS re-discovery.

## 5.4 SEAL functional requirements

[AR-5.4-a] The SEAL architecture shall leverage satellite connectivity.

[AR-5.4-b] The SEAL architecture shall support satellite coverage availability information during discontinuous coverage of satellite connectivity.

[AR-5.4-c] The SEAL architecture shall support UE unavailability information during discontinuous coverage of satellite connectivity.

[AR-5.4-d] The SEAL architecture shall support obtaining and exposing S&F events information regarding satellite connectivity in EPS.

[AR-5.4-e] The SEAL architecture shall support managing S&F message delivery regarding satellite connectivity in EPS.

# 6 Architecture for satellite access enabled 3GPP services and application enablers

## 6.1 Option#1: MC architecture over satellite access

### 6.1.1 Application architecture

The architecture and functional model defined in 3GPP TS 23.289 [23.289] is reused to achieve MC services over NTN.

### 6.1.2 Functional Elements

No additional functional elements is needed to be defined in order to enable MC services over NTN.

### 6.1.3 Reference Points

No additional reference point is needed to be defined in order to enable MC services over NTN.

## 6.2 Option#2: EDGEAPP over Satellite connectivity

### 6.2.1 Application enablement architecture and deployment models

The EDGEAPP architecture as defined in 3GPP TS 23.558 [10] is reused to enhance EDGEAPP procedures such as service provisioning, EAS discovery during satellite connectivity as per Solution #AE1, Solution #AE2, Solution #AE5 and Solution AE#7. There are no architectural impacts to EDGEAPP architecture defined in 3GPP TS 23.558 [10].

The EDGEAPP deployment models with satellite connectivity are as specified in:

- Clauses 7.2.1.1.1 and 7.2.7.1, where the ECS is deployed on ground while EES and EAS are deployed onboard satellite.

- Clause 7.2.5.1.1 where the ECS and EES are deployed on ground while EAS is deployed onboard satellite.

### 6.2.2 Functional Elements

Editor's Note: The functional elements corresponding to the architecture will be presented in this clause.

### 6.2.3 Reference Points

Editor's Note: The reference points corresponding to the architecture will be presented in this clause.

## 6.3 Option#3: SEAL over Satellite connectivity

### 6.3.1 Application enablement architecture and deployment models

The SEAL architecture as defined in 3GPP TS 23.434 [8] is reused to enhance SEAL procedures in Configuration management, Network resource management, SEALDD, to support discontinuous coverage, S&F operation during satellite connectivity as per Solution #AE3, Solution #AE4, Solution #AE6 and Solution AE#8. There are no architectural impacts to the SEAL architecture defined in 3GPP TS 23.434 [8].

The SEAL deployment models with satellite connectivity are as specified in:

- Clauses 7.2.4.1.1 and 7.2.8.1 where the SEAL and VAL servers are deployed on ground while PGW-U is deployed onboard satellite.

- Clause 7.2.6.1 where the MSGin5G server is deployed on ground while UPF is deployed onboard satellite.

### 6.3.2 Functional Elements

Editor's Note: The functional elements corresponding to the architecture will be presented in this clause.

### 6.3.3 Reference Points

Editor's Note: The reference points corresponding to the architecture will be presented in this clause.

# 7 Solutions

## 7.0 Mapping of solutions to key issues

Table 7.0-1 Mapping of solutions to key issues

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | KI #1 | KI #2 | KI #3 | KI #4 | KI#5 | KI#6 | KI#7 | KI#8 |
| Mission Critical Services | | | | |  |  |  |  |
| Sol #MC1 |  |  |  |  |  |  |  | x |
| Sol #MC2 |  |  |  |  |  |  |  |  |
| Application Enablers | | | | |  |  |  |  |
| Sol #AE1 |  | x |  |  | x |  |  |  |
| Sol #AE2 |  |  |  |  | x |  |  |  |
| Sol #AE3 |  |  | x |  |  |  |  |  |
| Sol #AE4 |  |  |  |  |  |  | x |  |
| Sol #AE5 | x | x |  |  |  |  |  |  |
| Sol #AE6 |  |  |  |  |  |  | x |  |
| Sol #AE7 | x | x |  |  |  |  |  |  |
| Sol #AE8 |  |  |  |  |  |  | x |  |
| Sol#AE9 | x |  |  |  |  |  |  |  |

## 7.1 Solutions for Mission Critical

### 7.1.1 Solution #MC1: MC group members NTN connection information

#### 7.1.1.1 Solution description

##### 7.1.1.1.1 General

This solution looks into how to inform MC group participants of one or more MC service users participating in the group communication being connected via NTN.

##### 7.1.1.1.2 Enhance the dynamic data associated with a group

Clause 10.1.5.5 in 3GPP TS 23.280 [18] discusses the dynamic data associated to a group, such as the status, i.e., the indication of potential emergency or in-peril status of the group, the affiliation status of each MC service ID in the group, ongoing group calls. These dynamic data is known to the MC service server and can be provided upon request.

The dynamic data associated with a group can be enhanced to include whether the affiliated MC service IDs are connected via NTN. This information is known at the MC service server and can be provided upon request.

NOTE 1: The MC service server may subscribe to notification events from the 5GC (in specific from PCF either directly or via NEF) to be informed whether the MC service UE is accessing MC services via satellite, as described in 3GPP TS 23.501 [5], 3GPP TS 23.502 [6] and 3GPP TS 23.503 [7].

NOTE 2: The P-Access-Network-Info SIP header may be enhanced to include satellite access network type. The P-Access-Network-Info is included in SIP messages to provide information about the access network type and is handled in stage 3.

#### 7.1.1.2 Solution evaluation

The solution described provides a promising approach to inform the participants of a group communication of possible MC service users being connected via NTN. The solution can be further enhanced, and potential procedures can be investigated during the normative work. Other potential solutions may be considered as well for the key issue.

## 7.2 Solutions for Application Enablers

### 7.2.1 Solution #AE1: Satellite edge computing

#### 7.2.1.1 Solution description

Editor's Note: This clause will describe the solution. Each solution should clearly describe which of the key issues it covers and how.

##### 7.2.1.1.1 General



Figure 7.2.1.1.1-1: satellite EDN deployment

In this deployment option, ECS is deployed on ground. The UE can be on the ground/sea or in the air (e.g. drone). The UPF to access satellite EDN is deployed on satellite, EAS and EES are deployed in one or more satellites. RAN (e.g. gNB) can either be deployed on ground/sea (e.g. in a ship) and connected to satellite UPF or be deployed on regenerative satellite (see Annex A and key issue #1 in 3GPP TR 23.700-29 [15]). The 5GS control plane functions (e.g. AMF, SMF) are deployed on the ground, which is not depicted in the figure for simplicity. EASs and their registered EES are deployed on one or more satellites which constitutes an EDN and these satellites’ coverage areas may correspond to an EDN service area. UPF can be deployed on ground to access the ECS, the EEC (in UE) can reach the ECS by EDGE-4 (on ground or via space).

If there are multiple EESs in a satellite EDN, EEC may trigger EAS discovery towards each EES which increases delay due to EDGE-1 interactions. It is recommended to deploy a single EES per EDN to reduce complexity in satellite.

NOTE: The UPF and RAN deployment are described above for the sake of clarity which is related to EDN on-board satellite (e.g. EDGE-4 path), see also 3GPP TS 23.501 [5] clause 5.43.2 and 3GPP TR 23.700-29 [15]).

During initial service discovery, the EEC (in UE) contacts the ECS via EDGE-4 (on ground or via space) to find an appropriate EES, then an appropriate EAS instance is selected during EAS discovery via EDGE-1 interaction. Finally, AC (in UE) communicates with the selected EAS.

Editor's Note: Other deployment options and associated latency aspects are FFS.

##### 7.2.1.1.2 Further consideration for service provisioning

An external server responsible for providing satellite availability information for each satellite based on real-time satellite orbit information (e.g. eccentricity, inclination, true anomaly) may exist (e.g. see 3GPP TS 23.501 [5], Annex Q). During service provisioning, the EEC can provide needed satellite capability information (e.g. satellite frequency bands) to the ECS and the ECS will be responsible to monitor UE location and UE moving prediction, and query the external server(s) to get a list of satellites (each identified by satellite ID) that can service the list of waypoints of the UE, then determine a suitable EES with a matching satellite ID to serve the UE with longest service time in service provisioning. Once the ECS identifies the suitable EES, it responds/notifies the EEC with the EES information. In addition, the corresponding ECS selected satellite ID is sent to the EEC.

Without external server, the EEC sends service provisioning request message, the request message contains the UE serving Satellite ID which is the Satellite ID connected by the UE, then the ECS can determine EES based on the UE serving Satellite ID and EES Satellite ID. Then the ECS sends the service provisioning response message to the EEC contains the identified EES. Alternatively, in the service provisioning procedure, the EEC sends service provisioning request message to the ECS as defined in 3GPP TS 23.558 [10] clause 8.3.3.2.2, then the ECS sends the service provisioning response message to the EEC contains list of EES along with EES Satellite ID. Upone receiving the response message, the EEC can determine EES based on the UE serving Satellite ID and EES Satellite ID.

Editor’s Note: how can UE obtain serving Satellite ID which is the gNB related Satellite ID is FFS.

##### 7.2.1.1.3 EAS discovery for EAS on board satellite

Unlike EAS discovery procedures EAS(s) on the ground, the EAS discovery for EAS(s) on board the satellite could be mobile depending on the satellite they are deployed on: GEO, MEO, or LEO. For GEO satellites, since the satellites are stationary relative to the Earth's surface, the EAS is also static. However, for MEO and LEO satellites, the EAS(s) are mobile as the satellites are moving relative to the Earth's surface. In this case, if the trajectory of the EAS is not considered for the discovery, frequent interruption, ACR, and/or service degradation may be experienced when there is a mismatch between the movement of the UE and the movement of the EAS on board satellite. This can be alleviated by considering the trajectory of the EAS on board satellite during the discovery. This solution is based on the assumption that the actual trajectory calculation for the satellite is performed by the satellite service provider and/or the operator. This trajectory calculation can be based on tlr-based mean orbital ephemeris, instantaneous/osculating ephemeris or any other means as per the satellite provider and/or operator. It is further assumed, the satellite provider and/or operator can also recommend a trajectory pattern that closely matches the planned route of the UE given the planned or expected route of a UE. The EEL does not need to deal with the actual trajectory calculation and only deals with trajectory ID that is provided by the satellite service provider and/or operator. This can be accomplished by adding mobility information and trajectory ID for the EAS in its profile.

1. EAS mobility: to indicate the mobile EASs (EAS on board MEO or LEO satellite) and non-mobile EAS (EAS on board GEO satellite and EAS on-ground)

2. Trajectory ID: to indicate the trajectory of the EAS on board MEO and LEO satellites. This trajectory ID is unique for each satellite and its trajectory.

NOTE 1: It is up to the satellite service provider or operator to associate the Trajectory ID with the actual trajectory of the satellite. The trajectory and position of the satellite can be calculated based on instantaneous/osculating ephemeris versus using TLE-based mean orbital ephemeris.

NOTE 2: The generation of the trajectory ID for the EAS(s) is done by the operator and/or the satellite service provider.

The Trajectory ID provided during the service provisioning response as per clause 7.2.1.1.4 can be provided by the EEC in the EAS discovery filters as per 3GPP TS 23.558 [10] clause 8.5.3.2 table 8.5.3.2-2. In case of EAS and EES deployed on the same satellite, the Trajectory ID provided matches the Trajectory ID of both EAS and the EES on board the satellite.

##### 7.2.1.1.4 Service provisioning for EES on board satellite

Similar to EAS on board a MEO or LEO satellite, the EES will also be mobile when the EES is also on board a MEO or LEO satellite. Therefore considering the trajectory of the EES is important for efficient service provisioning for selecting EDN matched with movement of the AC hosting UE during the AC’s operation schedule.

1. Dynamic service area indication: Indicates if the service area is dynamic or not. The service area is dynamic in case of EES on board a MEO or LEO satellite due to EES mobility and not dynamic in case of a EES on board a GEO satellite or EES on ground.

2. Trajectory ID: to indicate the trajectory of the EES on board MEO and LEO satellites. . This trajectory ID is unique for each satellite and its trajectory.

NOTE 1: It is up to the satellite service provider or operator to associate the Trajectory ID with the actual trajectory of the satellite. The trajectory and position of the satellite can be calculated based on instantaneous/osculating ephemeris versus using TLE-based mean orbital ephemeris.

NOTE 2: The generation and assignment of the trajectory ID for the EES(s) is done by the operator, the satellite service provider.

The "Expected AC Geographical Service Area" in the AC profile as in 3GPP TS 23.558 [10] clause 8.2.2 can be used by the ECS to request the external server (by the satellite service provider or operator) with list of trajectory IDs that match the UEs planned route and its location. The ECS then uses the list of the trajectory ID for the UE to provision EES(s) by matching the trajectory IDs in the EES profile with the list of the trajectory ID determined for the UE according to its position and its planned route. Furthermore, the list of the trajectory IDs are provided in the service provisioning response to be used for further EAS discovery as per clause 7.2.1.1.3.

#### 7.2.1.2 Architecture Impacts

This solution has no architecture impacts to EDGEAPP. Under the existing EDGEAPP architecture, the service provisioning procedure is enhanced to support different cases in service continuity.

#### 7.2.1.3 Corresponding APIs

##### 7.2.1.3.1 EAS Profile, EES Profile and AC Profile for discovery and service provisioning

According to clause 7.2.1.1.3 EAS discovery for EAS onboard satellite and clause 7.2.1.1.4 Service provisioning for EES on board satellite, the following change is needed in 3GPP TS 23.558 [10].

NOTE: The Trajectory ID of the EAS(s) and the EES(s) on the same satellite is identical.

- 3GPP TS 23.558 [10] Clause 8.2.4 EAS Profile EAS mobility on board LEO or MEO Satellite

3GPP TS 23.558 [10] Table 8.2.4-1: EAS Profile

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| EASID | M | The identifier of the EAS |
| EAS Endpoint | M | Endpoint information (e.g. URI, FQDN, IP address) used to communicate with the EAS. This information maybe discovered by EEC and exposed to ACs so that ACs can establish contact with the EAS. |
| EAS Type | O | The category or type of EAS (e.g. V2X, UAV, application enabler) |
| EAS description | O | Human-readable description of the EAS |
| … | … | … |
| **Dynamic service area indication** | **O** | **Indicates if the service area is dynamic or not. The service area is dynamic in case of EAS on board a MEO or LEO satellite and not dynamic in case of a GEO satellite.** |
| **Trajectory ID (NOTE 1)** | **O** | **For mobile EAS, indicates an identifier for that relates to trajectory of the EAS on board a MEO and LEO satellites.** |
| …  NOTE 1: The assignment of the trajectory ID for EAS(s) can be done by the operator and/or the satellite service provider. The trajectory and position of the satellite can be calculated for example based on instantaneous/osculating ephemeris versus using TLE-based mean orbital ephemeris. | | |

- 3GPP TS 23.558 [10] Clause 8.2.6 EES Profile EES and EAS mobility on board LEO or MEO Satellite

3GPP TS 23.558 [10] Table 8.2.6-1: EES Profile

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| EESID | M | The identifier of the EES |
| EES Endpoint | M | Endpoint information (e.g. URI, FQDN, IP address) used to communicate with the EES. This information is provided to the EEC to connect to the EES. |
| … | … | … |
| **Dynamic service area indication** | **O** | **Indicates if the service area is dynamic or not. The service area is dynamic in case of EES on board a MEO or LEO satellite and not dynamic in case of a GEO satellite.** |
| **Trajectory ID (NOTE 2)** | **O** | **For mobile EES, indicates the trajectory of the EES on board MEO and LEO satellites.** |
| …  NOTE 2: The assignment of the trajectory ID for the EES can be done by the operator and/or the satellite service provider. The trajectory and position of the satellite can be calculated for example based on instantaneous/osculating ephemeris versus using TLE-based mean orbital ephemeris. | | |

- 3GPP TS 23.558 [10] Clause 8.5.3 EAS discovery request

3GPP TS 23.558 [10] Table 8.5.3.2-2: EAS discovery filters

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| List of AC characteristics (NOTE 1) | O | Describes the ACs for which a matching EAS is needed. |
| > AC profile (NOTE 2) | M | AC profile containing parameters used to determine matching EAS. AC profiles are further described in Table 8.2.2-1. |
| … | … | … |
| List of EAS characteristics (NOTE 1, NOTE 3) | O | Describes the characteristic of required EASs. |
| … | … | … |
| **> Trajectory ID** | **O** | **Trajectory ID matching the trajectory of the UE which considers the current UE location as well as its planned route.** |

NOTE: The relationship between satellite ID and trajectory ID and whether the trajectory ID will merge into the satellite ID is to be determined in normative.

#### 7.2.1.4 Solution evaluation

This solution is for KI#2 and addresses the open issue about deployment option for EDGEAPP and related enhancements to the EDGEAPP procedures including service provisioning and EAS discovery. The solution does not impact the architecture entity in EDGEAPP.

The solution proposes ECS is deployed on ground while EAS and EES are deployed on satellite. In this solution the EEC can be provide satellite capability information during service provisioning and then ECS will monitor UE location and UE moving prediction to determine and provision matching satellite ID to serve. In case of NGSO satellites, EEC contacts the ECS to find appropriate EES and EAS is discovered considering trajectory of the EES and EAS using Trajectory ID to match with the movement of the UE, to avoid frequent interruption, and/or service degradation. The Trajectory ID is defined as a unique identifier assigned to each satellite and its orbit path in Medium Earth Orbit (MEO) and Low Earth Orbit (LEO). Both EAS and EES systems utilize this ID. The satellite operator or service provider is responsible for determining the trajectory and assigning the Trajectory ID.

The solution is feasible.

### 7.2.2 Solution #AE2: Enhancement for on board EES(s) and service provisioning

#### 7.2.2.1 Solution description

This solution proposes to address the following open issues in KI#5,

- How the EES(s) are placed on board the Satellite.

- Whether and how the service provisioning is impacted.​

It is proposed to add the Satellite assistant information in the EES profile to indicating the EES(s) are placed on board the satellite, so that, the ECS could do the service provisioning based on those Satellite assistant information.

##### 7.2.2.1.1 General

When EES is deployed in the satellite, it is proposed to add the Satellite assistant information in the EES Profile to indicating the EES is deployed on-board. The Satellite assistant information could be the satellite ephemeris information(e.g., time slot and spatial location). So that the ECS could obtain the EES’s Satellite assistant information during the EES registration.

Table 7.2.2.1.1-1: EES Profile

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| EESID | M | The identifier of the EES |
| EES Endpoint | M | Endpoint information (e.g. URI, FQDN, IP address) used to communicate with the EES. This information is provided to the EEC to connect to the EES. |
| EDN information | O | EDN information where the EES resides. |
| > DNN | M | Data network name to identify the EDN. |
| > DNAI(s) | O | DNAI(s) associated with the EDN. |
| EASIDs | M | List of EASIDs registered or expected to be registered with the EES. |
| >Allowed MNO information | O | Information of the allowed operator as described in EAS profile clause 8.2.4, Only subscribers from these operators can consume the EES services. |
| List of EAS bundle information | O | List of EAS bundles per EASID to which the EAS belongs and related bundling requirements. |
| > Bundle ID  (NOTE 2) | O | A bundle ID as described in clause 7.2.10. |
| > List of EASIDs  (NOTE 2) | O | List of EASIDs associated with the EAS bundle. |
| > Bundle type | M | Type of the EAS bundle as described in clause 7.2.10 |
| > EAS bundle requirements | O | Requirements associated with the EAS bundle as described in clause 8.2.10. |
| Instantiable EAS information | O | The EAS instantiation status per EASID (e.g. instantiated, instantiable but not be instantiated yet). |
| > Instantiation criteria (NOTE 1) | O | The criteria upon which EAS can be instantiated (e.g. based on specific date and time). |
| EEC registration configuration | M | Indicates whether the EEC is required to register on the EES to use edge services or not. |
| ECSP ID | O | The identifier of the ECSP that provides the EES. |
| EES Topological Service Area | O | The EES serves UEs that are connected to the Core Network from one of the cells included in this service area. EECs in UEs that are located outside this area shall not be served. See possible formats in Table 8.2.7-1. |
| EES Geographical Service Area | O | The area being served by the EES in Geographical values (as specified in clause 7.3.3.3) |
| List of EES DNAI(s) | O | DNAI(s) associated with the EES. This IE is used as Potential Locations of Applications in clause 5.6.7 of 3GPP TS 23.501 [2].  It is a subset of the DNAI(s) associated with the EDN, where the EES resides. |
| EES Service continuity support | O | Indicates if the EES supports service continuity or not. This IE indicates which ACR scenarios are supported by the EES, also indicates the EES ability (e.g. EAS bundle information) of handling bundled EAS ACR. |
| **Satellite assistant information** | **O** | **Assistant information indicating the EES is on-board, and could be used to calculate the satellite's position and movement. It could be the statistic satellite ephemeris information (e.g., signal quality metrics and orbital elements)** |
| NOTE 1: "Instantiation criteria" IE shall be present only when the value of "Instantiable EAS information" IE is "instantiable but not be instantiated yet".  NOTE 2: At least one of the IEs shall be present if EAS bundle information is provided. | | |

After that, when UE requests the service provisioning, the following changes may apply.

Pre-condition:

1. The ECS support the availability information calculation.



Figure 7.2.2.1.1-1: Service provisioning

- In step2, the ECS calculates the EES availability information based on the Satellite assistant information, and determines the EES based on the EES availability information so that the EES is accessible to the UE. The EES availability information indicates when and how the EES is available for the requesting EEC. It could be a sequence of time durations for each grid point where each time duration includes an indication of coverage availability or unavailability as discussed in Annex Q of 3GPP TS 23.501 [5].

- In step3, if the EES meet the requirement so that the on-board EES is selected by the ECS, the ECS should send the EES availability information to the EEC. The EEC can select one or more such EES(s) to perform EAS discovery based on EES availability information.

Since the EAS only registers to the EES on the same satellite, the registration of EAS is not affected. Regarding EAS discovery, EES selects the EAS(s) from those deployed on the same satellite. If there is no EAS meets the requirement, the request would fail.

#### 7.2.2.2 Architecture Impacts

This solution has no architecture impacts to EDGEAPP. Under the existing EDGEAPP architecture, the service provisioning procedure is enhanced to support different cases in service continuity.

#### 7.2.2.3 Corresponding APIs

EDN configuration information in the Service provisioning response needs to be changed as follows.

Table 8.3.3.3.3-2: EDN configuration information

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| EDN connection information (NOTE 1) | M | Information required by the UE to establish connection with the EDN. |
| > DNN/APN | M | Data Network Name/Access Point Name |
| > S-NSSAI | O | Network Slice information |
| > EDN Topological Service Area | O | The EDN serves UEs that are connected to the Core Network from one of the cells included in this service area. See possible formats in Table 8.2.7-1. |
| List of EESs | M | List of EESs of the EDN. |
| > EESID | M | The identifier of the EES |
| > EES Endpoint | M | The endpoint address (e.g. URI, IP address) of the EES |
| > EAS information (NOTE 2) | O | EAS registration and associated bundle information. |
| >> EASID | M | An EASID registered or expected to be registered with the EES. |
| >> List of EAS bundle information | O | List of EAS bundles to which the EAS belongs. |
| >>> Bundle ID  (NOTE 3) | O | Bundle ID as described in clause 7.2.10. |
| >>> List of EASIDs  (NOTE 3) | O | A list of the EASIDs of the EASs in the bundle. |
| > Application Group ID list (NOTE 5) | O | List of Application Group IDs associated with EAS |
| > Instantiable EAS information | O | The EAS instantiation status per EASID (e.g. instantiated, instantiable but not be instantiated yet) |
| >> Instantiation criteria (NOTE 4) | O | The criteria upon which EAS can be instantiated (e.g. based on specific date and time). |
| > ECSP ID | O | The identifier of the ECSP that provides the EES. |
| > EES Topological Service Area | O | The EES serves UEs that are connected to the Core Network from one of the cells included in this service area. EECs in UEs that are located outside this area shall not be served. See possible formats in Table 8.2.7-1. |
| > EES Geographical Service Area | O | The area being served by the EES in Geographical values (as specified in clause 7.3.3.3) |
| > List of EES DNAI(s) | O | DNAI(s) associated with the EES/EAS. This IE is used as Potential Locations of Applications in clause 5.6.7 of 3GPP TS 23.501 [2]. |
| > EES Service continuity support | O | Indicates if the EES supports service continuity or not. This IE also indicates which ACR scenarios are supported by the EES. |
| > EEC registration configuration | M | Indicates whether the EEC is required to register on the EES to use edge services or not. |
| > Security Credential | O | Indicates the security credential sent by the ECS. The security credential is used by EEC to communicate with the EES as specified in 3GPP TS 33.558 [23], clause 6.3. |
| **>EES Availability information (NOTE 6)** | **O** | **The available information of the EES, especially for the onboard EES. This information indicates when and where the EES would be available.** |
| Lifetime | O | Time duration for which the EDN configuration information is valid and supposed to be cached in the EEC. |
| NOTE 1: If the UE is provisioned or pre-configured with URSP rules by the HPLMN or serving SNPN, the UE handles the precedence between EDN connection info and URSP rules as defined in 3GPP TS 23.503 [12] clause 6.1.2.2.1. EDN connection info is considered to be part of UE Local Configurations.  NOTE 2: EAS information is limited to the EEC requested applications. If no AC profiles were present in the service provisioning request, the EAS information is subject to the ECSP policy (e.g. no EAS information or a subset of EAS information related to the EES).  NOTE 3: At least one of the IEs shall be present if EAS bundle information is provided.  NOTE 4: "Instantiation criteria" IE shall be present only when the value of "Instantiable EAS information" IE is "instantiable but not be instantiated yet".  NOTE 5: "Application Group ID list" IE shall be present when "Application Group profile" is included for "AC profile" in service provisioning request as specified in clause 8.3.3.3.2.  **NOTE 6: EES Availability information should avoid the need for frequent updates. It could be a sequence of periodical time durations for each grid point where each time duration includes an indication of coverage availability or unavailability as discussed in Annex Q of 3GPP TS 23.501 [5].** | | |

#### 7.2.2.4 Solution evaluation

This solution is for KI#5 and addresses the open issue about deployment option for EDGEAPP and related enhancements to the EDGEAPP service provisioning. The solution does not required new architecture entity in EDGEAPP.

The solution proposes ECS is deployed on ground while EAS and EES are deployed on satellite. In this solution the Satellite assistant information in EES profile is used by ECS to calculate EES availability information for the EEC requesting service provisioning. ECS then sends the EES availability information to the EEC.

The solution is feasible.

### 7.2.3 Solution #AE3: Support discontinuous coverage for satellite access

#### 7.2.3.1 Solution description

This solution addresses the KI#3: Satellite access with discontinuous coverage.

This solution shows how the application enabler obtaining the satellite related information (e.g., ephemeris) from the satellites, retrieving unavailability period for UE with satellite access then exposing to the VAL UE and the VAL server.

This solution is based on the following assumptions and principles:

- This solution main serves for IoT services and take the SEAL as the application enabler.

- The SEAL server has obtained the ephemeris for Satellites.

- The SEAL server is aware of VAL UE’s location.

In this solution, it’s assumed the SEAL server has obtained the satellite related information (e.g. ephemeris) from the satellite information provider (e.g. satellite service provider or the operators) and based on these information, the SEAL server could generate the satellite coverage availability information which can be indicated to the UE whether or not coverage is available for a specific satellite RAT Type for a particular location and time. The example of coverage availability information can refer to the Annex Q of 3GPP TS 23.501 [5]. And based on clause 5.4.13.2 of 3GPP TS 23.501 [5], the coverage availability information can be provided to a UE by an external server. That means the SEAL server could provision UE the coverage availability information if UE is using the satellite access.

From the ephemeris and Satellite coverage availability information, the SEAL server could retrieve the unavailability period (e.g., duration and start time) based on UE’s location and then provide to the VAL UE and expose to the VAL server to indicate them to consider the unavailability period when the VAL UE is using satellite access.

The clause of 7.2.3.1.1 specifies the SEAL server generates or formats the Satellite coverage availability information based on ephemeris from the satellite information provider and retrieve the unavailability period (e.g., duration and start time) based on UE’s location and expose it to the VAL UE and VAL server to guild their following actions.

##### 7.2.3.1.1 Procedure of SEAL Server generating Satellite coverage availability and unavailability period information

Pre-condition:

- SEAL Client has registered on SEAL server.

- The VAL server asks SEAL Server to provide VAL UE’s information (e.g. location data) periodically.

- The SEAL server is aware of the VAL UE’s location information.



Figure 7.2.3.1.1-1: Procedure of SEAL Server generating Satellite coverage availability and unavailability period information

0. Assume the SEAL server has obtained the ephemeris for Satellites.

1. The SEAL server may generate the satellite coverage availability information based on the obtained the ephemeris for Satellites and the VAL UE’s location data or shape them in a unified format in case it receives the satellite coverage availability information directly from different 3rd parties (e.g., different Satellite companies). The example of satellite coverage availability information can refer to the Annex Q of 3GPP TS 23.501 [5].

2. As the satellite coverage availability information could indicate to the UE whether the coverage is available for a particular location and time, the SEAL server configures the satellite coverage availability information to the VAL UE/ SEAL Client via satellite coverage availability information configuration request.

3. The SEAL Client acknowledges the SEAL server if it supports the satellite access.

4. Based on the ephemeris for satellites and Satellite coverage availability information, the SEAL server also could retrieve the unavailability period (e.g., unavailability period duration and start time for the unavailability period) to guild UE when it could trigger the UL service flow, in case the UE wants to get the unavailability period information directly.

5. The SEAL server sends the unavailability period information to the VAL UE/SEAL Client via unavailability period information configuration request.

6. The SEAL Client acknowledges the SEAL server if it supports the satellite access. And the SEAL Client will operate considering the unavailability period information (e.g. not send UL messages during the unavailability period).

7. If the VAL server asks to provide VAL UE’s information (e.g. location data) periodically, the SEAL server may notify the VAL server the unavailability period information of VAL UE which could indicate VAL server how to operate to minimize the service impact (e.g., extended data buffering, pending downlink data transferring).

##### 7.2.3.1.2 Procedure for AS handling UE unavailability period information

Pre-condition:

- Satellite coverage availability information (SCAI) is not yet configured on the UE or not supported by the UE.

- 5GC is aware of SCAI and UE location.



Figure 7.2.3.1.2-1: Procedure for AS handling UE unavailability period information

1. UE does not support SCAI provisioning or UE has not received SCAI configuration from the 5GC. Hence, cannot provide UE unavailability period to the AS for operating gracefully under a discontinuous coverage pattern.

2. AS (e.g. SEAL server) sends get UE unavailability request to the 5GC, including the UE/User identity and service identity for which UE has satellite access. AS can subscribe with 5GC to loss of coverage event subscription to get notified about the unavailability period or unavailability duration when certain events occur e.g. start of unavailability period or before certain duration in a particular location, as described in clause 5.4.1.4 of 3GPP TS 23.501 [5].

3. 5GC (e.g. NEF) checks if UE supports satellite access and then determines UE unavailability e.g. based on SCAI information and UE location.

4. 5GC sends get UE unavailability response including the UE unavailability information to the AS. Or when an event is triggered in the 5GC corresponding to the subscription in step 2, 5GC notifies to AS the unavailability period information e.g. duration/start time, as described in clause 5.4.1.4 of 3GPP TS 23.501 [5].

5. AS (e.g. SEAL server) sends the unavailability period information to the AS (e.g. VAL server), if required.

6. AS (e.g. SEAL server) uses the UE unavailability information for adjusting the application behaviour e.g. to trigger the downlink data delivery, bulky data exchanges can be deferred and planned during longer connectivity intervals, giving precedence to data suiting short connectivity intervals.

Editor's note: Co-ordination may be required with SA2.

#### 7.2.3.2 Architecture Impacts

This solution has no architecture impacts to the existing SEAL server (i.e. Configuration management and SEALDD server) when serving the IoT applications.

Under the existing SEAL architecture, the SEAL Configuration management and SEALDD procedures are enhanced to support satellite discontinuous coverage. E.g., the procedure of generating the satellite coverage availability information (SCAI) and UE unavailability period, querying the SCAI from the 5GC and exposing to the VAL server may be added.

#### 7.2.3.3 Corresponding APIs

Editor's note: This clause provides the corresponding APIs for supporting the solution.

#### 7.2.3.4 Solution evaluation

This solution is for KI#3 and addresses the open issue on how SEAL can obtain the satellite coverage availability information (SCAI) and retrieve unavailability period then provide it to the UE and VAL Server. In this solution the SEAL server (i.e. Configuration management SEALDD server) retrieves the UE unavailability information either based on SCAI or from the 5GC.

Further, the solution proposes the SCAI information can be notified to the VAL UE and VAL server considers UE unavailability information to adjust the application behaviour (e.g. extended data buffering, pending downlink data transferring, bulky data exchanges can be deferred and planned during longer connectivity intervals giving precedence to data suiting short connectivity intervals) to minimize the service impact.

The solution does not required new architecture entity in SEAL. And the impacted entities are VAL UE and the SEAL server (i.e. Configuration management and SEALDD server).

### 7.2.4 Solution #AE4: Application enablers provisioning and expose the satellite S&F events information

#### 7.2.4.1 Solution description

This solution addresses the KI#7: Usage of S&F events information for the application enablement. It mainly focuses on the following open issues.

- What is the S&F events information that can be utilized by the application enablers?

- Whether and how the S&F Satellite operation information can be exposed to the 3rd party/VAL server.

This solution shows how the application enabler provisioning the satellite S&F configuration to the VAL UE based on the service request initiated by the VAL server. And how the VAL UE and the VAL server take the received satellite S&F configuration and the satellite S&F status into consideration to minimize the service interruption (e.g., adjust the DL frequency, size of data).

This solution is based on the following assumptions and principles:

- Take the IoT service as an example for Satellite S&F operation as it is kind of delay-tolerant service.

- Take SEAL enabler to serve the IoT services.

NOTE: This solution also applies for other delay-tolerant services (e.g. SMS).

The procedure of 7.2.4.1.1 specifies the deployment model for this solution.

The procedure of 7.2.4.1.2 specifies the procedure of SEAL Server exposing the satellite S&F status to the VAL server.

The procedure of 7.2.4.1.3 specifies the procedure of SEAL Server provisioning the satellite S&F configuration.

##### 7.2.4.1.1 Deployment model



Figure 7.2.4.1.1-1: Deployment for satellite S&F operation for IoT services

For this solution, the SEAL server serving the IoT service is assumed to be deployed on the ground. The VAL server is deployed on the ground. The UE can be on the ground/sea or in the air (e.g. drone). The PGW-U to access the SEAL server is deployed on the satellite. The SCEF exposing satellite information to the SEAL server can be deployed on the satellite based on the conclusion of KI#2 in 3GPP TR 23.700-29[15]. RAN (e.g. eB) is deployed on regenerative satellite according to the conclusion of KI#1 in 3GPP TR 23.700-29 [15].

##### 7.2.4.1.2 Procedure of SEAL Server exposing the S&F status to the VAL server

Pre-condition:

- The SEAL client, the SEAL server and the VAL server all are deployed on the ground.

- The UPF/PGW-U in the 3GPP CN is deployed on the satellite.



Figure 7.2.4.1.2-1: Procedure of SEAL Server exposing the S&F status to the VAL server

1. The VAL server sends UE S&F status events subscription requests to the SEAL server. The subscription events may include the UE Registration status in S&F Mode, the status of Feeder Link, the expected Delivery/Delay Time, the maximum S&F data storage quota per UE, the trigger conditions, etc.

2. The SEAL server authorizes the subscription request from the VAL server and sends the subscription request to the VAL UE and/or the 3GPP CN respectively if the authorization is successful.

3. The SEAL client and/or 3GPP CN acknowledge the SEAL server with UE S&F status events subscription response. And report the requested UE S&F status events when the trigger conditions for subscription are met. E.g., the UE is registered in S&F mode which may reported via UE or 3GPP CN, the Feeder Link is not available, the expected Delay Time is 10s, and the present maximum S&F data storage quota on Satellite 1 per UE is 10G, estimated delivery time which are all exposed from 3GPP CN through NEF/SCEF. The estimated delivery time indicating the estimated time to send data from the UE to gateway or from gateway to UE as described in clause 8.2 of 3GPP TS 23.700-29 [15].

Editor's note: The UE S&F status events exposed from 3GPP CN depend on the progress of SA2 Rel-19 study.

4. The SEAL server stores or updates the received UE S&F events results.

5. The SEAL server may notify the VAL server for the received UE S&F events received in Step 3. The VAL server may take them into consideration and adjust the traffic transmission policies when there is DL data for the VAL UE as follows.

- The VAL server may pend the DL data transition when the UE is in S&F Mode;

- The VAL server may pend the DL data transition when the Feeder Link is not available;

- The VAL server may transmit the DL data volume smaller than maximum S&F data storage quota;

- The VAL server may re-transmit the pending DL data when the Feeder Link is available.

NOTE: The above actions of the VAL server are all out of 3GPP scope.

6. If the VAL server doesn’t subscribe the UE S&F status events or doesn’t support the S&F actions described in Step 5, the VAL server may send the DL data to the SEAL server even when e.g., the Feeder Link is not available.

7. The SEAL server checks the received UE S&F events status and takes the following corresponding actions based on the different status of events.

When feeder link is available, the SEAL server sends the DL data (e.g., bulk#1) towards the 3GPP network. At the same time, the NRM server starts an estimated delivery timer based on the estimated delivery time which is corresponding to the feeder link. The estimated delivery timer is greater than or equal to the estimated delivery time.

8a. The SEAL server may send “Pending DL data” request to the VAL server with the reason (e.g. the Feeder Link is not available, the UE is in S&F Mode), and estimated delivery timer is not expired) and the pending timer concluded from the expected Delivery/Delay Time will also be included.

8b. The SEAL server may send “Reject DL data” request to the VAL server with the failure reason (e.g. the Feeder Link is not available).

8c. The SEAL server may send “Forward DL data with the priority” request to the VAL server with the forwarding priories (e.g. when the DL data volume exceeds the maximum S&F data storage quota, only higher priorities services will be forwarded, such as the emergency service, VIP users).

8d. The SEAL server may send “Adjust DL data volume” request to the VAL server with the adjusted traffic volume which is smaller than the maximum S&F data storage quota (e.g. when the DL data volume exceeds the maximum S&F data storage quota, the smaller traffic volume will be suggested and adjusted). If estimated delivery timer expires, the SEAL server calculates the new DL data volume (e.g., increasing the volume by the data size (e.g., size of bulk#1) delivered with the previous estimated delivery time), and informs the VAL server the adjusted DL data volume.

7.2.4.1.3 Procedure of SEAL Server provisioning the satellite S&F configuration

According to the SA1 requirements in 3GPP TS 22.261[2], a trusted 3rd party could provide the S&F data retention period and/or the S&F data storage quota per UE/satellite basis. And some solutions of 3GPP TR 23.700-29[15] in SA2 have indicated the provisioning capability allows an external party to provision the information, such as expected UE behaviour and service specific parameters. So it is very necessary for the application enabled layer in SA6 to take SA1 requirements and SA2 solutions into consideration to provide the provision procedure for Store and Forward Satellite Specific Parameters in the application enabled layer.

This procedure takes the deployment model specified in clause 7.2.4.1.1 as baseline.

Pre-condition:

- The SEAL client, the SEAL server and the VAL server are deployed on the ground.

- The PGW-U in the 3GPP CN is deployed on the satellite.



Figure 7.2.4.1.3-1: Procedure of SEAL Server provisioning the satellite S&F   
configuration for the application layer

1. The VAL server initiates a monitor traffic volume request for certain VAL UE to ask the VAL UE to report the used traffic volume periodically. The service request may include the UE identification, the UE type (i.e. IoT), the expected data transmission period, the maximum volume of data transmission within a certain period of time, etc.

2. The SEAL server may take advantage of the service request initiated by the VAL server in Step 1 and the obtained satellite information (e.g. ephemeris) in Sol#3 to decide the on-board S&F parameters for the application layer (e.g., maximum S&F data storage quota per UE/satellite, maximum S&F data retention per UE/satellite, etc.) as follows:

- The maximum S&F data storage quota may be concluded based on the maximum volume of data transmission within a certain period of time in the service request;

- The maximum S&F data retention per UE/service may be concluded via the data transmission period in the service request and the satellite information (e.g. ephemeris);

NOTE 1: How the SEAL server determining the satellite S&F parameters is internal implementation.

3. The SEAL server acknowledges the VAL server with a monitor traffic volume response.

4. The SEAL server provisions the determined satellite S&F parameters to the VAL UE.

5. The SEAL client stores the received satellite S&F parameters and takes them into consideration when the VAL UE starts to perform the S&F operations.

NOTE 3: How the VAL UE determining the S&F parameters is internal implementation. The VAL UE may consider its pre-configuration, and the received parameters from the network to decide its satellite S&F configuration.

6. Similar with Step 1, the VAL server may update the monitor traffic volume request for certain VAL UE with the updated parameters (e.g. data transmission period, the maximum volume of data transmission).

7. Similar with Step 2, the SEAL server updates the on-board S&F parameters based on received information in Step 6.

8. Same with Step 3. The SEAL server acknowledges the VAL server with a monitor traffic volume response with optional updated on-board S&F parameters.

9. Same with Step 4. The SEAL server provides the updated on-board S&F parameters to the VAL UE.

#### 7.2.4.2 Architecture Impacts

This solution has no architecture impacts to SEAL. Under the existing SEAL architecture, the SEAL NRM for control plane, SEALDD sever for user plane procedures are enhanced to support S&F functionality during satellite connectivity.

#### 7.2.4.3 Corresponding APIs

Editor's note: This clause provides the corresponding APIs for supporting the solution.

#### 7.2.4.4 Solution evaluation

This solution is for KI#7 and addresses the open issue about enabling SEAL architecture to obtain and expose the S&F related information and to leverage that information for optimised application enablement behaviour. The solution does not required new architecture entity in SEAL.

This solution proposes how SEAL server (NRM server for control plane, SEALDD sever for user plane) obtains UE S&F events information and then how such information is used by the SEAL server (NRM server for control plane, SEALDD sever for user plane) to minimize the service interruption (e.g., adjust the DL frequency, size of data, message acknowledgement handling, ack timers). The UE S&F status events exposed from 3GPP CN depend on the progress of SA2.

Furthermore, this solution also proposes how SEAL server (i.e. configuration server) provisions the satellite S&F configuration to the VAL UE to instruct the VAL UE to perform the S&F operation properly.

The solution is feasible.

### 7.2.5 Solution #AE5: Satellite edge computing considering EAS onboard

#### 7.2.5.1 Solution description

##### 7.2.5.1.1 General

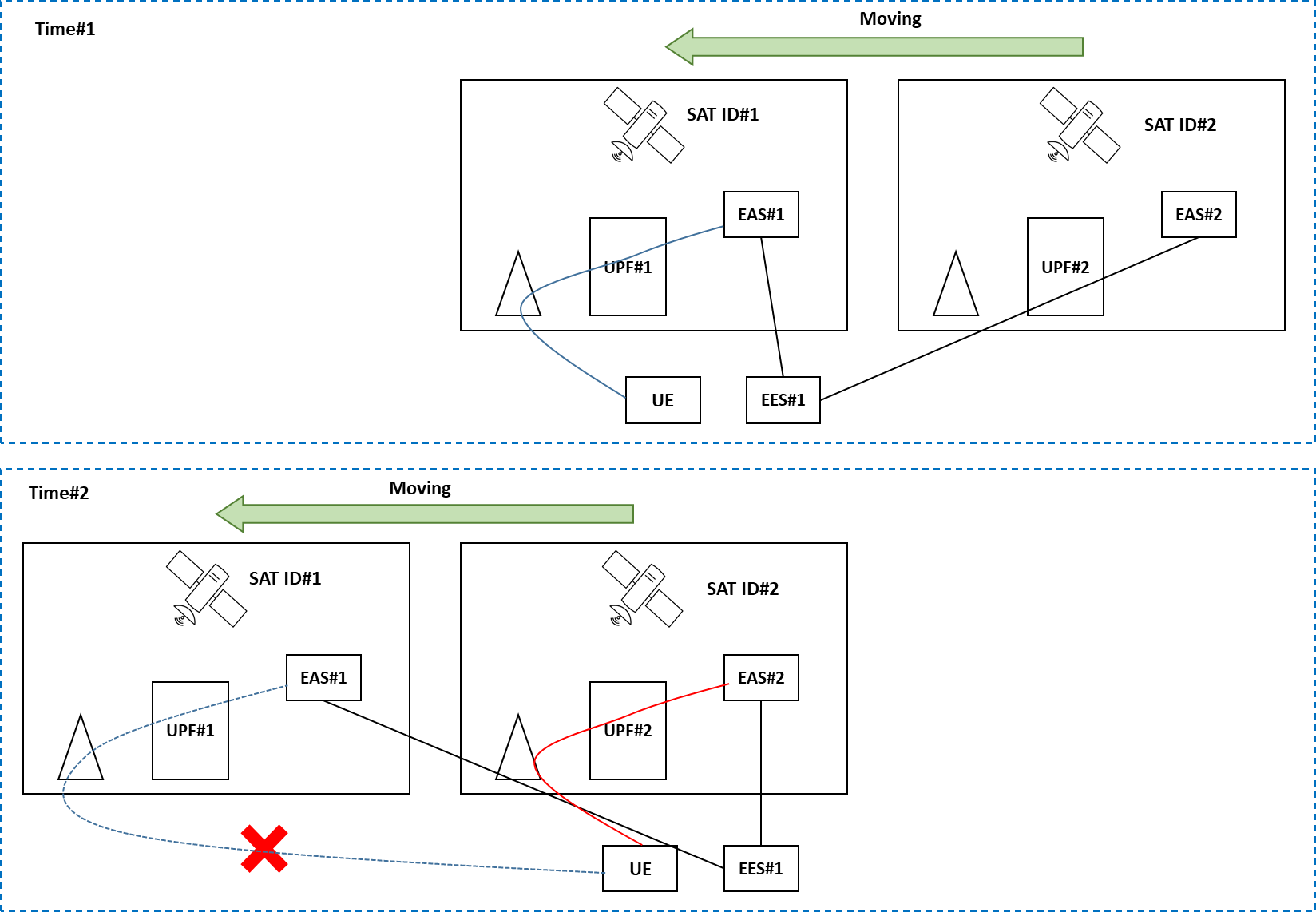


Figure 7.2.5.1.1-1: EAS onboard satellite deployment

In this deployment option, ECS and EES are deployed on ground. The UE can be on the ground/sea or in the air (e.g. drone). The UPF to access EAS is deployed on satellite. RAN (e.g. gB) can either be deployed on ground/sea (e.g. in a ship) and connected to satellite UPF. The 5GS control plane functions (e.g. AMF, SMF) are deployed on the ground, which is not depicted in the figure for simplicity. UPF can be deployed on ground to access the ECS and EES, the EEC (in UE) can reach the ECS by EDGE-4 (on ground or via space), and EEC (in UE) can reach the EES by EDGE-1 (on ground).

Considering that EAS(s) deployed in multiple MEO or LEO satellites, so that the EAS(s) are mobile as the satellites are moving relative to the Earth's surface. In this case, if the ephemeris information of the EAS is not considered for the discovery, frequent interruption may be experienced when there is a mismatch between the movement of the UE and the movement of the EAS on board satellite.

As for the EAS on MEO and LEO satellites however the EES is on the ground, in the EAS discovery procedure, the EES can determine a list of EAS based on the UE (predicted/expected) location, Prediction expiration time, Satellite ID and EAS ephemeris information and the EES provide list of EAS information in the EAS discovery response message. Upon receiving a list of EAS information, the UE can determine the EAS based on the UE (predicted/expected) location, Prediction expiration time, EAS Satellite ID and EAS ephemeris information, and UE may sequentially connect to corresponding EAS based on ephemeris information of the EASs. When an EAS is about to leave the UE’s location, the UE may connect to a next EAS in advance to obtain an edge computing service, and does not need to perform EAS discovery again. In doing so, the service interruption caused by periodic EAS discovery can be avoided.

Besides, the EEC can send Satellite ID in service provisioning request message to the ECS for EES information.

In addition, when a serving satellite is providing EAS and due to discontinuous coverage the same satellite comes back for serving, then the EEC connects to same EAS (i.e. to which the EEC had previously connected to), without needing to discover EAS endpoints again.

#### 7.2.5.2 Architecture Impacts

This solution has no architecture impacts to EDGEAPP. Under the existing EDGEAPP architecture, the EAS discovery procedure is enhanced to support different cases in discontinuous coverage.

#### 7.2.5.3 Corresponding APIs

##### 7.2.5.3.1 EAS Profile enhancement for EAS onboard

According to clause 7.2.1.1.3 EAS discovery for EAS onboard satellite the following change is needed in TS 23.558 [10].

- 3GPP TS 23.558 [10] Clause 8.2.4 EAS Profile EAS mobility on board LEO or MEO Satellite

3GPP TS 23.558 [10] Table 8.2.4-1: EAS Profile

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| EASID | M | The identifier of the EAS |
| EAS Endpoint | M | Endpoint information (e.g. URI, FQDN, IP address) used to communicate with the EAS. This information maybe discovered by EEC and exposed to ACs so that ACs can establish contact with the EAS. |
| EAS Type | O | The category or type of EAS (e.g. V2X, UAV, application enabler) |
| EAS description | O | Human-readable description of the EAS |
| … | … | … |
| **Satellite ID** | **O** | **The Satellite ID corresponding to the EAS.** |
| **ephemeris information** | **O** | **The ephemeris information of the satellite corresponding to the EAS** |
| …  NOTE 1: The assignment of the trajectory ID for EAS(s) can be done by the operator and/or the satellite service provider. The trajectory and position of the satellite can be calculated for example based on instantaneous/osculating ephemeris versus using TLE-based mean orbital ephemeris. | | |

#### 7.2.5.4 Solution evaluation

This solution is for KI#2 to addresses the open issue about deployment option for EDGEAPP and related enhancements to the EDGEAPP procedures including service provisioning and EAS discovery. The solution does not required new architecture entity in EDGEAPP.

The solution proposes ECS and EES are deployed on ground while EAS is deployed on satellite. In this solution the EES on the ground determines the list of EAS e.g. corresponding to the UE’s predicted location information then provides to the UE satellite IDs matching the UEs predicted location. EEC then connects to the appropriate EAS corresponding to the location according to the satellite IDs and avoids repeating EAS discovery for each location. Further the solution also avoids repeating EAS discovery by EEC re-connecting to the previously connected EAS associated to a satellite, when the same satellite returns in coverage after discontinuous coverage.

As for this deployment case, the each EES need to maintain all the EAS information which deployed on the satellite which is not feasible. Editor's note: The procedures and the use of the satellite ID and ephemeris information in the procedures is FFS.

### 7.2.6 Solution #AE6: Enhancing store and forward mechanism of MSGin5G service

#### 7.2.6.1 Solution description

As specified in clause 8.3.6 (of 3GPP TS 23.554 [14]), SA6 defined MSGin5G service supports application enabler level store and forward mechanism. As per the defined mechanism, the MSGin5G server stores the message if recipient UE is not available. Further, as specified in KI #7, SA2 is studying S&F events like expected delivery time (including Feeder-Link Availability to deliver data, Service-Link Availability to deliver data, etc).

There can be scenario where recipient UE is connected to satellite in store and forward mode as shown in Figure 7.2.6.1.1-1.



Figure 7.2.6.1.1-1: Store and Forward scenario for MSGin5G service

In such case, MSGin5G server can subscribe to S&F events to know when feeder link to recipient UE is available and also what is the expected time of the delivery.

Based on this information, the message originator can decide to do one of the following:

1) If the expected delivery time is after the message expiry time, and the message is important to be delivered according to the originating user, the message originator can request the MSGin5G server to increase the store and forward parameters; Otherwise, the message originator can request the MSGin5G server to discard the stored message.

##### 7.2.6.1.2 Enhancement to MSGin5G Store and Forward procedure

Following enhancement are done in clause 8.3.6 of 3GPP TS 23.554 [14]:

- The MSGin5G server subscribes to receive S&F events:

- If the recipient MSGin5G Client knows that satellite connection may be used, e.g. based on the configuration, it may include the satellite connection used indicator in its registration request. The related registration enhancement is specified in clause 7.2.6.1.4. In this case, MSGin5G server subscribes the S&F events after the procedure of MSGin5G Client registration.

NOTE: In this case, the subscription is a long-lived subscription, i.e. the subscription will expire only if the MSGin5G Client is de-registered. Subscription per message is not needed. It may reduce the subscription frequency between the MSGin5G Server and core network.

- Otherwise, for each received Message towards to the recipient MSGin5G Client which is connected to satellite, after step-2 in clause 8.3.6 of 3GPP TS 23.554 [14], the MSGin5G server subscribes to receive S&F events (e.g. feeder link availability, expected delivery time) as per clause 6.38.2 of 3GPP TR 23.700-29 [15].

- Upon receiving S&F events to the MSGin5G server from the NEF, the MSGin5G server sends a delivery status message to the MSGin5G client. The message includes the message ID, recipient UE identity and expected delivery time to deliver the message. The user of the UE or the MSGin5G client considers this information and may decide to update the store and forward parameters (as specified in clause 7.2.6.1.3) or may decide to discard the stored message (as specified in clause 7.2.6.1.4).

Editor's note: The solution depends on progress of SA2 study.

##### 7.2.6.1.2 Procedure for MSGin5G client to update the store and forward parameters

Figure 7.2.6.1.2-1 shows the procedure for MSGin5G client to update the store and forward parameters.

Pre-conditions:

1. The MSGin5G Client has originated a message to a recipient UE and it is stored to the MSGin5G Server as the recipient UE is not available (as specified in clause 8.3.6 of 3GPP TS 23.554 [14]).

2. User has received notification from the MSGin5G server about Feeder Link Available event and expected delivery time.



Figure 7.2.6.1.2-1: MSGin5G update stored message parameters

0. The user or the application client decides to update the store and forward parameters based on the received expected delivery time event about the recipient UE. The application client informs MSGin5G client to update the store and forward parameters.

1. The MSGin5G client sends a request message to update the store and forward parameters to the MSGin5G server. The message includes the message ID for which store and forward parameters needs to be updated, and new/updated store and forward parameters (e.g. Message expiration time) as specified in Table 8.3.2-2 3GPP TS 23.554 [14].

2. Upon receiving the request, the MSGin5G server checks whether the message is stored based on received message ID. If message is stored, then it updates the store and forward parameters and sends response back to the MSGin5G client. If the MSGin5G client is not authorized to update the parameters or the message does not exists, then the response message includes failure cause.

##### 7.2.6.1.3 Procedure for MSGin5G client to discard the stored message

Figure 7.2.6.1.3-1 shows the procedure for MSGin5G client to discard the stored messages.

Pre-conditions:

1. The MSGin5G Client has originated a message to a recipient UE and it is stored to the MSGin5G Server as the recipient UE is not available (as specified in clause 8.3.6 of 3GPP TS 23.554 [14]).

2. User has received notification from the MSGin5G server about Feeder Link Available event and expected delivery time of the recipient UE.



Figure 7.2.6.1.3-1: MSGin5G discard stored message

0. The user or the application client decides to discard the stored message based on the received expected delivery time event about the recipient UE. The application client informs MSGin5G client discard the stored message.

1. The MSGin5G client sends a request message to discard the stored message to the MSGin5G server. The message includes the message ID which needs to be discarded. The request message also includes reason for discarding the stored message.

2. Upon receiving the request, the MSGin5G server checks whether the message is stored based on received message ID. If message is stored, then it discards the stored message and sends response back to the MSGin5G client. If the MSGin5G client is not authorized to update the parameters or the message does not exists, then the response message includes failure cause.

##### 7.2.6.1.4 Enhancement to MSGin5G UE Registration

If the recipient MSGin5G Client knows that satellite connection may be used, e.g. based on the configuration, it may include the satellite connection used indicator in its registration request. This indicator is included in the MSGin5G Client Communication Availability specified in Table 8.2.1-3 of 3GPP TS 23.554 [14].

Table 8.2.1-3 of 3GPP TS 23.554 [14]: MSGin5G Client Communication Availability

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| Scheduled communication time | M | Time when the UE becomes available for communication. |
| Communication duration time | M | Duration time of periodic communication. |
| Periodic communication indicator | O | Identifies whether the client communicates periodically or not, e.g., on demand. |
| Periodic communication interval | O | Interval Time of periodic communication. This IE is mandatory if the Periodic communication indicator indicates periodic communications. |
| Data size indication | O | Indicates the expected data size to be exchanged during the communication duration. |
| Store and forward option | O | Indicates opting out of store and forward services for incoming MSGin5G requests. The MSGin5G Server uses the information to determine whether Store and Forward procedure applies as specified in clause 8.3.6. |
| Satellite connection used | O | Indicates whether satellite connection will be used by this MSGin5G Client. |

#### 7.2.6.2 Architecture Impacts

No architecture impact is identified for MSGin5G architecture as defined in 3GPP TS 23.554 [14].

#### 7.2.6.3 Corresponding APIs

Table 7.2.6.3-1 specifies information elements for MSGin5G update stored message parameter request message.

Table 7.2.6.3-1: MSGin5G update stored message parameter request

|  |  |  |
| --- | --- | --- |
| **Information element** | **Status** | **Description** |
| Originating UE Service ID/AS Service ID | M | The service identity of the sending MSGin5G Client or the sending Application Server. |
| Message ID | M | Unique identifier of the stored message for which parameters needs to be updated |
| Store and forward parameters | M | Updated parameters used by MSGin5G Server for providing store and forward services, as detailed in table 8.3.2-2 of 3GPP TS 23.554 [14]. |

Table 7.2.6.3-2 specifies information elements for MSGin5G update stored message parameter response message.

Table 7.2.6.3-2: MSGin5G update stored message parameter response

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| Result | M | Indication if the procedure is success or failure |
| Failure Cause (see NOTE) | O | The reason for failure |
| NOTE: This IE shall only be present when the result is Failure. | | |

Table 7.2.6.3-3 specifies information elements for MSGin5G discard stored message request message.

Table 7.2.6.3-3: MSGin5G discard stored message request

|  |  |  |
| --- | --- | --- |
| **Information element** | **Status** | **Description** |
| Originating UE Service ID/AS Service ID | M | The service identity of the sending MSGin5G Client or the sending Application Server. |
| Message ID | M | Unique identifier of the stored message for which parameters needs to be updated |

Table 7.2.6.3-4 specifies information elements for MSGin5G discard stored message response message.

Table 7.2.6.3-4: MSGin5G discard stored message response

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| result | M | Indication if the procedure is success or failure |
| Failure Cause (see NOTE) | O | The reason for failure |
| NOTE: This IE shall only be present when the result is Failure. | | |

#### 7.2.6.4 Solution evaluation

This solution addresses key issue #7 by utilizing store and forward events from SA2, and deciding whether to update the stored and forward parameters or the MSGin5G message or discard the stored message. Solution #AE6 will not be considered for KI #7 in normative phase due to SA2 only support S&F for EPC in Rel-19.

### 7.2.7 Solution #AE7: Satellite edge computing considering EAS onboard

#### 7.2.7.1 Solution description

##### 7.2.7.1.1 General



Figure 7.2.7.1.1-1: EAS and EES onboard satellite deployment

In this deployment option, ECS is deployed on ground. The UE can be on the ground/sea or in the air (e.g. drone). The UPF to access satellite EDN is deployed on satellite, EAS and EES are deployed in one or more satellites. EASs and their registered EES are deployed on one or more satellites.

As for the EAS and EES on MEO or LEO satellites however the ECS is on the ground, in the service provisioning procedure, the ECS can determine a list of EES based on the UE (predicted/expected) location, Prediction expiration time, Satellite ID and EES ephemeris information and ECS provide list of EES information in the service provisioning response message. Upon receiving a list of EES information, the EEC can determine the EAS based on the UE (predicted/expected) location, Prediction expiration time, EAS Satellite ID and EAS ephemeris information, then the UE may sequentially connect to corresponding EESs based on ephemeris information of the EESs. When an EES is about to leave the UE’s location, the UE may connect to a next EES in advance to obtain an edge computing service, and does not need to perform EES discovery again. In doing so, the service interruption caused by periodic EES discovery can be avoided.

Furthermore, the EES can indicate the ECS whether the EAS and EES are deployed in the same Satellite, if the EES and EAS are deployed in the same satellite, then the ECS can provide EAS information (EAS endpoint and EAS ephemeris information) along with the EES information. Upon receiving the EAS information, the UE can connect to the EAS and the EAS discovery procedure does not need to be performed.

In addition, when a serving satellite is providing EES and EAS, and due to discontinuous coverage the same satellite comes back for serving, then the EEC connects to same EES and EAS (i.e. to which the EEC had previously connected to), without needing to discover EES and EAS endpoints again.

Besides, the EEC can send Satellite ID in EAS discovery request message to the EES for EAS information.

NOTE: The method to determine the predicted/expected UE location can be referred to in the provisioning section of 3GPP TS 23.558 [10].

#### 7.2.7.2 Architecture Impacts

This solution has no architecture impacts to EDGEAPP. Under the existing EDGEAPP architecture, the service provisioning and EAS discovery procedures are enhanced to support different cases in discontinuous coverage.

#### 7.2.7.3 Corresponding APIs

##### 7.2.7.3.1 EES Profile enhancement for EES onboard

According to clause 7.2.7.1 service provisioning for EES onboard satellite the following change is needed in 3GPP TS 23.558 [10].

3GPP TS 23.558 [10] Clause 8.2.6 EES Profile EES mobility on board LEO or MEO Satellite

3GPP TS 23.558 [10] Table 8.2.6-1: EES Profile

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| EESID | M | The identifier of the EES |
| EES Endpoint | M | Endpoint information (e.g. URI, FQDN, IP address) used to communicate with the EES. This information is provided to the EEC to connect to the EES. |
| … | … | … |
| **Satellite ID** | **O** | **The Satellite ID corresponding to the EES.** |
| **ephemeris information** | **O** | **The ephemeris information of the satellite corresponding to the EES** |
| …  NOTE 2: The assignment of the trajectory ID for the EES can be done by the operator and/or the satellite service provider. The trajectory and position of the satellite can be calculed for example based on instantaneous/osculating ephemeris versus using TLE-based mean orbital ephemeris. | | |

#### 7.2.7.4 Solution evaluation

This solution is for KI#2 to addresses the open issue about deployment option for EDGEAPP and related enhancements to the EDGEAPP procedures including service provisioning and EAS discovery. The solution does not required new architecture entity in EDGEAPP.

The solution proposes ECS is deployed on ground while EES and EAS are deployed on satellite. In this solution the ECS on the ground determines the list of EES e.g. corresponding to the UE’s predicted location information, and then provides to the UE satellite IDs matching the UEs predicted location. EEC then connects to the appropriate EES to determine EAS corresponding to the location according to the satellite IDs and avoids repeating EAS discovery for each location. Further the solution also avoids repeating EAS discovery by EEC re-connecting to the previously connected EAS associated to a satellite, when the same satellite returns in coverage after discontinuous coverage.

The solution is feasible.

Editor's note: The procedures and the use of the satellite ID and ephemeris information in the procedures is FFS.

### 7.2.8 Solution #AE8: Leveraging S&F events information at application enablement

#### 7.2.8.1 Solution description

This solution maps to KI#7. This solution is about leveraging S&F events information at the application enablement for the optimized service delivery. In this scenario, AS (e.g. SEAL server) is considered to be deployed on the ground and UPF onboard the satellite as shown in Figure 7.2.8.1-1.



Figure 7.2.8.1-1: Deployment scenario

##### 7.2.8.1.1 AS subscribing to S&F events information with EPC



Figure 7.2.8.1.1-1: Procedure for AS subscribing to S&F events information with EPC

1. AS (e.g. SEAL server) sends subscribe S&F information request to EPC (e.g. SCEF) e.g. for getting feeder link and service link availability information, expected data delivery time.

NOTE: The request may include UE information if AS (e.g. SEAL server) is subscribing to events related to a specific UE.

2. EPC then authenticates and authorizes the AS requesting to receive S&F information.

3. EPC sends success or failure response to the AS related to the request made in step 1. If S&F information is available then the success response may also include the S&F information e.g. for getting feeder link and service link availability information, expected data delivery time.

4. EPC monitors the occurrence of any event related to S&F.

5. Upon occurrence of any event related to S&F, EPC sends S&F information e.g. for getting feeder link and service link availability information, expected data delivery time towards AS.

##### 7.2.8.1.2 S&F data delivery handling at AS

Pre-condition: AS (SEAL server) has subscription to S&F information with EPC as described in 7.2.8.1.1



Figure 7.2.8.1.2-1: Procedure for S&F data delivery handling at AS (e.g. SEAL server)

1. VAL server sends send data request to AS (e.g. SEAL server) including the target UE/user and service identity information.

2. AS (e.g. SEAL server) may store the received data request. AS (e.g. SEAL server) may optimize application/service behaviour e.g. adjust the frequency/timing of sending data, adjust the data size.

3. AS (e.g. SEAL server) provides send data response to VAL sever e.g. the estimated delivery time information, adjust the data size.

NOTE: AS (e.g. SEAL server) may send an acknowledgement to the VAL server after the data delivery request at step 1 is eventually delivered to the target UE/user.

Editor’s note:   The S&F events information exposed from 3GPP CN depend on the progress of SA2 Rel-19 study.

#### 7.2.8.2 Architecture Impacts

This solution has no architecture impacts to SEAL. Under the existing SEAL architecture, the SEALDD procedures are enhanced to support S&F functionality during satellite connectivity.

#### 7.2.8.3 Corresponding APIs

Editor's note: This clause provides the corresponding APIs for supporting the solution.

#### 7.2.8.4 Solution evaluation

This solution is for KI#7 and addresses the open issue about enabling SEAL architecture to obtain and expose the S&F related information and to leverage that information for optimised application enablement behaviour. The solution does not required new architecture entity in SEAL.

This solution proposes how SEAL server (NRM, SEALDD server) obtains UE S&F events information from EPC and then how such information is used by the SEAL server (NRM, SEALDD server) to minimize the service interruption (e.g., adjust the DL frequency, size of data, message acknowledgement handling, ack timers). The UE S&F status events exposed from 3GPP CN (i.e. EPC) depend on the progress of SA2.

The solution is feasible.

### 7.2.9 Solution #AEx: Analytics related to UE RAT connectivity

#### 7.2.9.1 Solution description

This solution addresses the open issues listed as part of the key issue 1 which are related to identifying the new analytics required to be supported for satellite access. It introduces a new analytics type which needs to be supported by the ADAE (Application Data Analytics Enablement) server. It proposes the procedure for supporting the UE RAT connectivity analytics by the ADAE server which can be consumed by the analytics consumers (e.g. VAL server) in-order to provide a better service experience over satellite access. This analytics helps to predict the type of satellite RAT that a UE will latch to on a particular location and/or particular time and helps the analytics consumer to decide on certain action. Some of the examples of the action could be as below:

- Extended data buffering

- Pending downlink data transferring

- Whether to schedule a communication with the UE

- QoS adaption

##### 7.2.9.1.1 Procedure on UE RAT connectivity analytics

Figure 7.2.9.1.1-1 illustrates the procedure support the UE RAT connectivity analytics.



Figure 7.2.9.1.1-1: Procedure of ADAE Server supporting UE RAT connectivity analytics

1. The analytics consumer (e.g.VAL server) makes a subscription request to ADAE server for UE RAT connectivity prediction/stats, including an analytics event ID for UE RAT Connectivity analytics. The request may include also the target area, a target VAL service, or a VAL UE, or group of UEs of the VAL service, time validity. If the VAL UEs are provided by the VAL server, this request may also include the expected route or a set of waypoints for the UEs of the VAL application.

2. The ADAE server sends a UE RAT connectivity analytics subscription response as an ACK to the VAL server.

3. The ADAE server subscribes to the SEAL Location management server to get the location information of the VAL UE along with the RAT type. It can set the trigger criteria of receiving the location information of the UE whenever UE RAT type changes as specified in 3GPP TS 23.434 [7] clause 9.3.5.

4. The ADAE server subscribes for NWDAF UE mobility analytics per VAL UE (for all the VAL UEs) and gets notification on the per UE location/mobility analytics based on 3GPP TS 23.288 [2] clause 6.7.2.

5. If the data is collected from multiple sources, the ADAES combines or correlates the data/analytics from steps 3-4 and stores the data into A-ADRF if needed.

6. The ADAE server optionally requests UE RAT connectivity historical analytics /data from A-ADRF for the corresponding VAL UEs.

7. Based on the request, the ADAE server receives UE RAT connectivity historical analytics /data from A-ADRF for the corresponding VAL UEs.

8. The ADAE server abstracts or correlates the data/analytics from steps 5-6 and provides analytics on the UE RAT connectivity for the target VAL application.

9. The ADAE server sends the location accuracy analytics notification to the consumer

#### 7.2.9.2 Architecture Impacts

This solution has no architecture impacts to ADAE or any other SEAL services.

#### 7.2.9.3 Corresponding APIs

##### 7.2.9.3.1 General

The following information flows are specified for UE RAT connectivity analytics.

##### 7.2.9.3.2 UE RAT Connectivity analytics subscription request

Table 7.2.9.3.2-1 describes information elements for the UE RAT connectivity analytics subscription request from the VAL server / Consumer to the ADAE server.

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| VAL server ID | M | The identifier of the VAL server. |
| Analytics ID | M | The identifier of the UE RAT connectivity analytics event. |
| VAL UE ID(s) or Group ID | M | The identity of the VAL UE(s) or group of UEs for which the analytics subscription applies |
| VAL service ID | O | The identifier of the VAL service for which location accuracy analytics is requested. |
| Preferred confidence level | O | The level of accuracy for the analytics service (in case of prediction). |
| Area of Interest | O | The geographical or service area for which the subscription request applies. |
| Time validity | O | The time validity of the subscription request. |
| UE mobility / route information | O | Information on the target UE or group UE mobility including the expected route/set of waypoints. |
| Reporting requirements | O | It describes the requirements for analytics reporting. This requirement may include e.g. the type and frequency of reporting (periodic or event triggered), the reporting periodicity in case of periodic, and reporting thresholds. |

##### 7.2.9.3.3 UE RAT Connectivity analytics subscription response

Table 7.2.9.3.3-1 describes information elements for the UE RAT connectivity analytics subscription response from the ADAE server to the VAL server /Analytics Consumer.

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| Result | M | The result of the analytics subscription request (positive or negative acknowledgement) |

##### 7.2.9.3.4 UE RAT Connectivity data request

Table 7.2.9.3.4-1 describes information elements for the UE RAT connectivity data request from the ADAE server to the A-ADRF.

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| ADAE server ID | M | The identifier of the ADAE server |
| Analytics ID | M | The identifier of the analytics event i.e. UE RAT connectivity analytics |
| List of VAL UE IDs and addresses | M | The VAL UE(s) identifiers and IP address(es) for which the data/analytics apply |
| VAL service ID | O | The service ID, in case of requesting historical data for a particular VAL service. |
| Reporting configuration | O | The configuration for data reporting. This requirement may include e.g. the frequency of reporting (periodic), the reporting periodicity in case of periodic, and reporting thresholds, whether data abstraction is needed or not. |
| Data collection requirements | O | The requirements for data collection, including the format of data, frequency of reporting, level of abstraction of data, level of accuracy of data. |
| Area of Interest | O | The geographical or service area for which the subscription request applies |
| Time validity | O | The time validity of the request |

##### 7.2.9.3.5 UE RAT Connectivity data response

Table 7.2.9.3.5-1 describes information elements for the UE RAT connectivity data response from the A-ADRF to the ADAE server.

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| Analytics ID | M | The identifier of the analytics event. |
| List of VAL UE IDs and addresses | M | The VAL UE(s) identifiers and IP address(es) for which the analytics apply |
| VAL service ID | O | The service ID, in case of requesting historical data for a particular VAL service. |
| Analytics Output | M | The reported analytics for the UE RAT connectivity, which can be in form of offline stats/historical data for a specific VAL service or for particular UE(s) or group of UEs |

##### 7.2.9.3.6 UE RAT Connectivity analytics notification

Table 7.2.9.3.5-1 describes information elements for the UE RAT connectivity analytics notification from the A-ADRF to the ADAE server.

|  |  |  |
| --- | --- | --- |
| Information element | Status | Description |
| Analytics ID | M | The identifier of the analytics event (UE RAT connectivity) |
| Analytics Output | M | The predictive or statistical parameter, which can be:  - A predicted or expected RAT type changes for a particular UEs for a given waypoints  - A predicted or expected RAT Type UE would latch on for a given time period or location |
| Confidence level | O | For predictive analytics, the achieved confidence level can be provided. |

#### 7.2.9.4 Solution evaluation

Editor's note: This clause provides an evaluation of the solution. The evaluation should include the descriptions of the impacts to existing architectures.

This solution is for KI#1 and addresses the open issues about the new analytics required to be supported for satellite access. This solution does not impact the architecture of ADAE or any other SEAL services.

The solution proposes and new analytics ID for the UE RAT connectivity. The analytics consumer can request the ADAE server for gathering the UE RAT connectivity analytics stats/predictions for a UE or set of UEs. The ADAE server interacts with the NWDAF and SEAL LMS for getting the mobility analytics and location of the UE whenever its RAT connectivity changes. It also fetches the historical analytics data from A-ADRF and derives at the UE RAT connectivity analytics stats/predictions. The solution is feasible.

# 8 Deployment scenarios

## 8.1 General

The architecture shall support deployment of application enablers and services over satellite connectivity.

## 8.2 Deployment model

See clauses 6.1, 6.2 and 6.3.

# 9 Business Relationships

## 9.1 EDGEAPP deployment with satellite connectivity

The business relationship for EDGEAPP deployment with satellite connectivity described below is in addition to the description in clause B.1 of 3GPP TS 23.558 [10].



Figure 9.1-1: Relationships involved in edge computing service with satellite connectivity

The PLMN operator can have satellite service agreement with the satellite service provider to offer his services e.g. to serve the unconnected areas.

The Edge computing service provider can have satellite service agreement with the satellite service provider to deploy EDGEAPP components onboard satellite e.g. to enable Application service provider to provide seamless experience to end users.

## 9.2 SEAL deployment with satellite connectivity

The business relationship for SEAL deployment with satellite connectivity.



Figure 9.2-1: Relationships involved in VAL services with satellite connectivity

The PLMN operator can have satellite service agreement with the satellite service provider to offer his services e.g. to serve the unconnected areas.

The SEAL provider can have satellite service agreement with the satellite service provider to enable SEAL to leverage satellite services to provide enhanced experience to end users of VAL services e.g. S&F, wider coverage.

Editor's Note: Provide a description of the involved business relationships including applicability to Mission Critical or Application Enablers.

# 10 Overall evaluation

## 10.1 Architecture evaluations for Mission Critical

Option#1 in clause 6.1 discusses MC architecture to enable MC services over NTN. There are no impacts identified to the existing architecture in 3GPP TS 23.289 [19] for providing MC services over satellite access.

## 10.2 Key issue evaluations for Mission Critical

### 10.2.1 Key issue #4:

There is no solution specified in this study.

### 10.2.2 Key issue #8:

The solution #MC1 described provides a promising approach to inform the participants of a group communication of possible MC service users being connected via NTN. The solution can be further enhanced, and potential procedures can be investigated during the normative work. Other potential solutions may be considered as well for the key issue.

## 10.3 Architecture evaluations for Application Enablers

Option#2 in clause 6.2 addresses architecture for EDGEAPP over satellite connectivity. The EDGEAPP architecture as defined in 3GPP TS 23.558 [10] is reused to enhance EDGEAPP procedures such as service provisioning, EAS discovery during satellite connectivity as per Solution #AE1, Solution #AE2, Solution #AE5 and Solution AE#7. There are no architectural impacts to EDGEAPP architecture defined in 3GPP TS 23.558 [10].

Option#3 in clause 6.3 addresses architecture for SEAL over satellite connectivity. The SEAL architecture as defined in 3GPP TS 23.434 [8] is reused to enhance SEAL NRM, Configuration management and SEALDD procedures to support discontinuous coverage, S&F operation during satellite connectivity as per Solution #AE3, Solution #AE6, and Solution AE#8. There are no architectural impacts to the SEAL architecture defined in 3GPP TS 23.434 [8].

## 10.4 Key issue evaluations for Application Enablers

### 10.4.1 Key issue #1:

Solution #AE9 addresses the open issues for the key issue #1. It defines a new analytics for the UE RAT connectivity and proposes the procedures for the ADAE server. The solution proposed in this study will be added as part of 3GPP TS 23.436 [20].

### 10.4.2 Key issue #2:

Solution #AE1, Solution #AE5 and Solution #AE7 addresses key issue #2.

Solution #AE1, Solution #AE5 and Solution #AE7 resolves open issue to investigate different deployment options for EDGEAPP. Solution #AE1 and Solution #AE7 proposes ECS is deployed on ground while EAS and EES are deployed on satellite.

Solution #AE5 proposes ECS and EES are deployed on ground while EAS is deployed on satellite. More detailed study of this scenario is required before adding this solution to normative.

Solution #AE1 (where ECS is deployed on ground while EAS and EES are deployed on satellite), Solution #AE5 (where where ECS and EES are deployed on ground while EAS is deployed on satellite) and Solution #AE7 (where ECS is deployed on ground while EAS and EES are deployed on satellite) resolves open issue to optimise EAS discovery in different deployment scenarios.

Solution #AE1 and Solution #AE7 can be considered for normative work which are for proposing different deployment scenarios and optimized EAS discovery.

### 10.4.3 Key issue #3:

Solution #AE3 addresses key issue #3.

Solution #AE3 resolves open issue about application enabler (SEAL Configuration management server) obtaining the satellite coverage availability information and to retrieve unavailability period for UE (either from UE or from the 5GS), for supporting satellite discontinuous coverage. Further the solution also resolves open issue about leveraging UE unavailability period information for minimizing the service impact or adjusting the application behaviour by the SEALDD server. There is dependency with SA2 for obtaining exposure of loss of coverage event information.

Solution #AE3 can be considered for normative work.

### 10.4.4 Key issue #5:

Solution #AE1 and Solution #AE2 addresses key issue #5.

Solution #AE1 resolves open issue to investigate deployment option ECS is deployed on ground while EAS and EES are deployed on satellite for EDGEAPP and optimise EDGEAPP behaviour by enhancing both EDGEAPP service provisioning and EAS discovery procedures.

Solution #AE2 resolves open issue to investigate deployment option where ECS is deployed on ground while EAS and EES are deployed on satellite for EDGEAPP and optimise EDGEAPP behaviour by enhancing EDGEAPP service provisioning procedures.

Both Solution #AE1and Solution #AE2 can be considered for normative work.

### 10.4.5 Key issue #6:

Editor's Note: This clause will provide evaluation of different solutions for KI#6.

### 10.4.6 Key issue #7:

Solution #AE4, Solution #AE6 and Solution #AE8 addresses key issue #7.

Solution #AE4, Solution #AE6 and Solution #AE8 resolves open issue to obtain the S&F events information and to utilize S&F events information to optimise application enablement behaviour.

Solution #AE4 proposes how SEAL (NRM, Configuration Server, SEALDD) server obtains UE S&F events information and then how such information is used by the SEAL (NRM, Configuration Server, SEALDD) server to minimize the service interruption.

Solution #AE6 proposes to utilize S&F events for MSGin5G service over 5G and optimizes the behaviour by deciding to update or discard already stored message. Solution #AE6 will not be considered for KI #7 in normative phase since SA2 supports S&F only for EPC in Rel-19.

Solution #AE8 proposes how SEAL (NRM, SEALDD) server obtains UE S&F events information from EPC and then how such information is used by the SEAL (NRM, SEALDD) server to minimize the service interruption.

Solution #AE4 and Solution #AE8 can be considered for normative work which are for considering different approaches on how SEAL (NRM, Configuration Server, SEALDD) server obtains UE S&F events information and then how such information is used by the SEAL (NRM, Configuration Server, SEALDD) server to minimize the service interruption.

# 11 Conclusions

## 11.1 General conclusions

This clause provides conclusions for the study of supporting deployment of application enablers and services over satellite connectivity.

## 11.2 Conclusions for Mission Critical

### 11.2.1 General conclusions for MC services over NTN

Annex A has provided several information and recommendations related to the satellite access support for MC services. As satellite characteristics, e.g., altitude, play a significant role in introducing propagation delays and have direct impact on MC KPIs, NGSO satellites (e.g., LEO, MEO) may be the most suitable ones for MC services.

The existing architecture defined in 3GPP TS 23.289[19] is suitable to enable MC services over NTN without any impact. The support of MC services over NTN can be included in the normative work within Rel-19.

### 11.2.2 Conclusions of key issue #4

There is no solution specified in this study.

### 11.2.3 Conclusions of key issue #8

The solution #MC1 described provides a promising approach to inform the participants of a group communication of possible MC service users being connected via NTN. The solution can be further enhanced, and potential procedures can be investigated during the normative work. Other potential solutions may be considered as well the key issue.

## 11.3 Conclusions for Application Enablers

### 11.3.1 Architecture conclusions

The study concludes with following architectural considerations for the normative work:

- There are no architectural changes required to the EDGEAPP architecture defined in 3GPP TS 23.558 [10] for supporting satellite connectivity. The EDGEAPP architecture defined in 3GPP TS 23.558 [10] can be reused for supporting satellite connectivity.

- There are no architectural changes required to the SEAL architecture defined in 3GPP TS 23.434 [8] for supporting satellite connectivity. The SEAL architecture defined in 3GPP TS 23.434 [8] can be reused for supporting satellite connectivity.

### 11.3.2 Conclusions of key issue #1 and #2

The study concludes with following solution considerations for the normative work:

- Solution #AE1

- Solution #AE7 and

- Solution #AE9.

The study concludes that Solution#AE5 requires more detailed study of this scenario before adding this solution to normative.

### 11.3.3 Conclusions of key issue #3

The study concludes with following solution considerations for the normative work:

- Solution #AE3.

### 11.3.4 Conclusions of key issue #5

The study concludes with following solution considerations for the normative work:

- Solution #AE1 and

- Solution #AE2.

### 11.3.5 Conclusions of key issue #6

There is no solution specified in this study.

### 11.3.6 Conclusions of key issue #7

The study concludes with following solution considerations for the normative work:

- Solution #AE4 and

- Solution #AE8.

Annex A (informative): Information related to Satellite access support for MC Service

# A.1 Propagation delay over satellite

As per current 3GPP specifications 3GPP TS 22.261 [2] and 3GPP TS 23.501 [5], mobile communication is possible via satellite access, where there is a connectivity between the UE and the satellite. Accordingly, 5G services are possible over both Terrestrial Network (TN) and Non-Terrestrial Network (NTN). In NTN, non-Geo stationary Orbit (NGSO) satellites are placed into Low-Earth Orbit (LEO) typically at an altitude between 300 km to 2000 km, Medium-Earth Orbit (MEO) typically at altitudes between 8000 to 20000 km. The Geostationary Earth Orbit (GEO) satellites are placed at 35786 km altitude. Utilizing satellite access is beneficial to increase network coverage and availability of the services. However, connectivity via satellite introduces additional propagation delays compared to the connectivity established via terrestrial network.

The propagation delay via satellite associated with different orbit is as below as discussed in 3GPP TS 22.261 [2]:

Table A.1-1: Satellite propagation delays

|  |  |  |  |
| --- | --- | --- | --- |
|  | 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 |
| NOTE 1: The serving satellite provides the satellite radio link to the UE  NOTE 2: delay between UE and ground station via satellite link; inter satellite links are not considered | | | |

Satellite systems of relatively low altitude, e.g., LEO, can offer relatively lower latency, which can be the most beneficial choice for latency sensitive services such as MC services.

Furthermore, unlike GEO, NGSO satellites (LEO and MEO) satellites are moving with respect to the ground. Therefore, it is necessary to have a constellation of several NGSO satellites associated with the MC service under consideration to ensure proper service continuity over the non-terrestrial networks. Consequently, a specific geographical area will be covered through satellite beams created by different NGSO satellites over time.

Following KPIs are requirements for MC service as specified in 3GPP TS 22.179 [11]:

Table A-2: Mission Critical KPIs

|  |  |  |
| --- | --- | --- |
| KPI 1 | MCPTT Access time | < 300 ms |
| KPI 2 | End-to-end MCPTT Access time | < 1000 ms |
| KPI 3 | Mouth-to-ear latency | < 300 ms |
| KPI 4a | Maximum Late call entry time (without application layer encryption) | < 150 ms |
| KPI 4b | Maximum Late call entry time (with application layer encryption) | < 350 ms |

MC services are not restricted only to the ones defined in this clause and such services can also have priority treatment, if defined via operator's policy and/or local regulation. Priority treatment for MC Services require appropriate ARP and 5QI (plus 5G QoS characteristics) setting for QoS Flows according to the operator's policy. As per 3GPP TS 23.501 [5], the following 5QIs are proposed for catering mission critical KPIs:

Table A.1-3: 5QIs catering Mission Critical KPIs

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 5QI  Value | Resource Type | Default Priority Level | Packet Delay Budget | Packet Error  Rate | Default Maximum Data Burst Volume | Default  Averaging Window | Example Services |
| 69 | Non-GBR | 5 | 60 ms | 10-6 | N/A | N/A | Mission Critical delay sensitive signalling (e.g. MC-PTT signalling) |
| 8 | Non-GBR | 80 | 300 ms | 10-6 | N/A | N/A | Video (Buffered Streaming)  TCP-based (e.g. www, e-mail, chat, ftp, p2p file sharing, progressive |
| 65 | GBR | 7 | 75 ms | 10-2 | N/A | 2000 ms | Mission Critical user plane Push To Talk voice (e.g. MCPTT) |
| 67 | GBR | 15 | 100 ms | 10-3 | N/A | 2000 ms | Mission Critical Video user plane |
| 4 | GBR | 50 | 300 ms | 10-6 | N/A | 2000 ms | Non-Conversational Video (Buffered Streaming) |
| 70 | Non-GBR | 55 | 200 ms | 10-6 | N/A | N/A | Mission Critical Data (e.g. example services are the same as 5QI 6/8/9) |
| 10 | Non-GBR | 90 | 1100ms | 10-6 | N/A | N/A | Video (Buffered Streaming)  TCP-based (e.g. www, e-mail, chat, ftp, p2p file sharing, progressive video, etc.) and any service that can be used over satellite access type with these characteristics |

Considering MCPTT Access time and Mouth to ear latency KPI requirements, which are less than 300 ms, the consumption of MC services might be impacted when MC service users are connected via, e.g., GEO satellite due to the corresponding propagation delay.

# A.2 Geometrical coverage of satellite

NTN provides larger coverage in comparison to TNs. In general, the coverage provided by NTN may correspond to up to tens of thousands of TN cells. Therefore, NTN can be considered an efficient approach in providing MC services over multicast and broadcast sessions for a large area, especially large area which suffers of poor to no TN coverage (e.g., in extremely rural areas, natural disasters, etc.)

As discussed in 3GPP TS 22.822 [3], the theoretical geometrical coverage of a satellite depends on its altitude and its minimum elevation angle, i.e., the angle which the satellite is seen by the MC service UE above the horizon, as explained in Figure A.2-1.

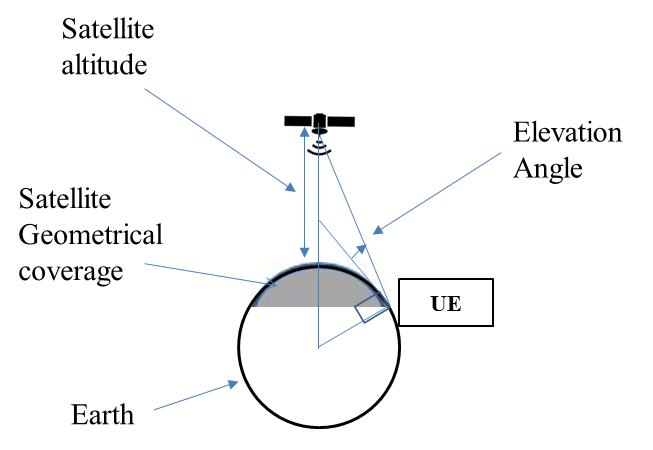


Figure A.2-1: Illustration of the geometrical coverage of a satellite

Furthermore, table A.2-1 presents the elevation angle (in degrees) and altitude of different satellite types (LEO, MEO and GEO) and their corresponding distance (satellite to MC service UE in km), propagation delay (in msec) and geometrical coverage radius (in km).

Table A.2-1: UE to satellite distances, propagation delays and geometrical coverage radii for different satellite types based on their altitude and elevation angle.



Furthermore, Table A.2-2 illustrates the number of satellites needed in a constellation to provide continuous global coverage for an elevation angle ranging from 5 to 10 degrees.

Table A.2-2: Illustration of number satellites in a constellation for continuous Earth coverage



The coverage of NTN is further described in other references, e.g., 3GPP TR 38.821 [12], and 3GPP TS 38.811 [13].

Annex B (informative):  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2023-11 | SA6#58 | S6-233765 |  |  |  | Proposed skeleton for FS\_5GSAT\_Ph3\_APP (23.700-01) | 0.0.0 |
| 2024-01 |  |  |  |  |  | After FS\_5GSAT\_Ph3\_APP was approved at SA#102 Plenary (December 2023) all pCRs approved at SA6#58 are implemented in TR 23.700-01 V0.1.0 | 0.1.0 |
| 2024-01 |  | S6-233944 |  |  |  | FS\_5GSAT\_Ph3\_APP\_Scope | 0.1.0 |
| 2024-01 |  | S6-234109 |  |  |  | New KI on Application enabled for services over satellite access | 0.1.0 |
| 2024-01 |  | S6-234090 |  |  |  | New KI on Enabling re-discovery and re-allocation of EASs on-board satellites | 0.1.0 |
| 2024-01 |  |  |  |  |  | References [2]-[10] added. | 0.1.0 |
| 2024-03 | SA6#59 | S6-240350 |  |  |  | FS\_5GSAT\_Ph3\_App\_editorials | 0.2.0 |
| 2024-03 | SA6#59 | S6-240740 |  |  |  | FS\_5GSAT\_Ph3\_App\_update-KI#1 | 0.2.0 |
| 2024-03 | SA6#59 | S6-240733 |  |  |  | New KI on satellite access with discontinuous coverage | 0.2.0 |
| 2024-03 | SA6#59 | S6-240604 |  |  |  | pCR on KI for satellite backhaul support for MC services | 0.2.0 |
| 2024-03 | SA6#59 | S6-240741 |  |  |  | New Key Issue on Edge on board NGSO Satellite | 0.2.0 |
| 2024-03 | SA6#59 | S6-240742 |  |  |  | Satellite edge computing | 0.2.0 |
| 2024-04 | SA6#60 | S6-241591 |  |  |  | KI update with service continuity | 0.3.0 |
| 2024-04 | SA6#60 | S6-241646 |  |  |  | New KI: Support of UE-Satellite-UE communication for IMS services via Satellite access | 0.3.0 |
| 2024-04 | SA6#60 | S6-241620 |  |  |  | New KI: Usage of S&F events information for the application enablement | 0.3.0 |
| 2024-04 | SA6#60 | S6-241655 |  |  |  | Update Sol#AE1 (KI#5): Satellite Edge computing | 0.3.0 |
| 2024-04 | SA6#60 | S6-241595 |  |  |  | Update Sol#AE1 (KI#5, KI#2): Satellite Edge computing | 0.3.0 |
| 2024-04 | SA6#60 | S6-241419 |  |  |  | New Sol for KI#5: Enhancement for on board EES(s) and service provisioning | 0.3.0 |
| 2024-04 | SA6#60 | S6-241596 |  |  |  | New solution for KI#3 to support discontinuous coverage for satellite access | 0.3.0 |
| 2024-04 | SA6#60 | S6-241658 |  |  |  | Annex-B: Information related to Satellite access support for MC Service | 0.3.0 |
| 2024-05 | SA6#61 | S6-242555 |  |  |  | New KI#8 on impact on Mission Critical group communication KPIs | 0.4.0 |
| 2024-05 | SA6#61 | S6-242557 |  |  |  | Solution#AE1 Update: List of Trajectory ID during the Service Provisioning and EAS discovery | 0.4.0 |
| 2024-05 | SA6#61 | S6-242558 |  |  |  | Update Sol#AE3 to indicate how the SEAL server obtains the Satellite information | 0.4.0 |
| 2024-05 | SA6#61 | S6-242584 |  |  |  | New Solution#AE4 for KI#7 to use the S&F events information for the application enablement | 0.4.0 |
| 2024-05 | SA6#61 | S6-242587 |  |  |  | Update Annex B: Satellite access characteristics for MC services | 0.4.0 |
| 2024-05 | SA6#61 | S6-242696 |  |  |  | New Solution#AE5 for KI#2: Satellite edge computing considering EAS onboard | 0.4.0 |
| 2024-05 | SA6#61 | S6-242697 |  |  |  | New Solution#AE6 for KI#7: on enhancing MSGin5G service based on satellite S&F events | 0.4.0 |
| 2024-05 | SA6#61 | S6-242726 |  |  |  | Update of Solution#AE3 | 0.4.0 |
| 2024-06 | SA6#61 | S6-242755 |  |  |  | New Solution#AE7 for KI#2: Solution on Satellite edge computing EES onboard | 0.5.0 |
| 2024-06 | SA6#61 | S6-242756 |  |  |  | New Solution#AE8 for KI#7: Leveraging S&F events information at application enablement | 0.5.0 |
| 2024-06 | SA#104 | SP-240735 |  |  |  | Submitted to SA#104 for information | 1.0.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240108 |  |  |  | Adding missing abbreviations and minor edits | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240119 |  |  |  | Adding business relationship considering EDGEAPP/SEAL deployment with satellite connectivity. | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240263 |  |  |  | Sol#AE3 architecture impacts and solution evaluation | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240264 |  |  |  | Sol#AE4 update to supplement the procedure of the S&F parameters provisioning | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240306 |  |  |  | Adding architecture requirements | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240307 |  |  |  | Adding architecture options | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240308 |  |  |  | Adding solution#AE1 evaluation | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240309 |  |  |  | Adding solution#AE2 evaluation | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240314 |  |  |  | Adding deployment scenarios | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240315 |  |  |  | Adding overall evaluation - architecture | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240317 |  |  |  | Adding overall evaluation – KI#2 | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240318 |  |  |  | Adding overall evaluation – KI#3 | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240319 |  |  |  | Adding overall evaluation – KI#5 | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240321 |  |  |  | Adding conclusions | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240357 |  |  |  | Sol#AE2 update | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240358 |  |  |  | IE alignement for Sol#AE1 | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240359 |  |  |  | Adding Solution#AE4 evaluation | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240360 |  |  |  | Adding Solution#AE5 evaluation | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240361 |  |  |  | Update to Solution#AE6 and conclusion for KI 7 | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240362 |  |  |  | Adding Solution#AE7 evaluation | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240363 |  |  |  | Adding Solution#AE8 evaluation | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240364 |  |  |  | Adding overall evaluation – KI#1 | 1.1.0 |
| 2024-07 | SA6#62-Ad Hoc-e | S6a240365 |  |  |  | Adding overall evaluation – KI#7 | 1.1.0 |
| 2024-08 | SA6#62 | S6-243076 |  |  |  | TR editorial corrections in 7.2.4.1 and 7.2.5.1 | 1.2.0 |
| 2024-08 | SA6#62 | S6-243438 |  |  |  | Adding units to the table in the TR Annex A2 | 1.2.0 |
| 2024-08 | SA6#62 | S6-243719 |  |  |  | Adding MC architecture requirements | 1.2.0 |
| 2024-08 | SA6#62 | S6-243441 |  |  |  | Adding Solution#MC1 addressing KI#8 and KI#4 | 1.2.0 |
| 2024-08 | SA6#62 | S6-243711 |  |  |  | Adding MC architecture over satellite access | 1.2.0 |
| 2024-08 | SA6#62 | S6-243443 |  |  |  | MC overall evaluation | 1.2.0 |
| 2024-08 | SA6#62 | S6-243750 |  |  |  | MC overall conclusions | 1.2.0 |
| 2024-08 | SA6#62 | S6-243195 |  |  |  | Deployment model update for the Application enablement architecture | 1.2.0 |
| 2024-08 | SA6#62 | S6-243560 |  |  |  | Resolve Editor’s notes in Solution#AE1 | 1.2.0 |
| 2024-08 | SA6#62 | S6-243695 |  |  |  | Update Sol#AE4 about estimated delivery time | 1.2.0 |
| 2024-08 | SA6#62 | S6-243561 |  |  |  | Solution#AE4 evaluation update | 1.2.0 |
| 2024-08 | SA6#62 | S6-243562 |  |  |  | Remove EN2 in 7.2.6.1.2 and update of Solution #AE6 | 1.2.0 |
| 2024-08 | SA6#62 | S6-243563 |  |  |  | Adding an editor's note in subclause 7.2.7.1.1 | 1.2.0 |
| 2024-08 | SA6#62 | S6-243653 |  |  |  | Solution#AE1 update | 1.2.0 |
| 2024-08 | SA6#62 | S6-243654 |  |  |  | Adding open issues to KI#1 | 1.2.0 |
| 2024-08 | SA6#62 | S6-243655 |  |  |  | New Solution for KI#1 | 1.2.0 |
| 2024-08 | SA6#62 | S6-243318 |  |  |  | Deployment scenarios update | 1.2.0 |
| 2024-08 | SA6#62 | S6-243696 |  |  |  | Evaluation and conclusion on Key issue #2 | 1.2.0 |
| 2024-08 | SA6#62 | S6-243197 |  |  |  | Update overall evaluation for the KI#7 | 1.2.0 |
| 2024-08 | SA6#62 | S6-243319 |  |  |  | Update of general conclusion | 1.2.0 |
| 2024-09 | SA#105 | SP-241202 |  |  |  | Submitted to SA#105 for approval | 2.0.0 |
| 2024-09 | SA#105 | SP-241202 |  |  |  | MCC Editorial update for publication after TSG SA approval (SA#105) | 19.0.0 |