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| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on charging aspects of satellite in 5GS  (Release 18) | |
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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 studies on charging aspects of satellite in 5GS based on the TS 23.501 [2] and TS 23.502 [3]:

This study item is to investigate the following aspects of the satellite access:

- Possible business scenarios;

- Possible charging scenarios and potential charging requirements;

- Identify the potential charging solutions.

This study item is to investigate the following aspects of the satellite backhaul:

- Possible business scenarios;

- Possible charging scenarios and potential charging requirements, e.g. related to PCC/QoS control enhancement;

- Identify the potential charging solutions.

# 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 23.501: "System Architecture for the 5G System; Stage 2".

[3] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[4] 3GPP TS 22.261: "Service requirements for next generation new services and markets; Stage 1".

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

[6] 3GPP TR 23.700-27: "Study on 5G System with Satellite Backhaul".

[7] 3GPP TR 23.700-28: "Study on Integration of satellite components in the 5G architecture".

[8] 3GPP TR 23.737: "Study on architecture aspects for using satellite access in 5G".

[9] 3GPP TS 23.548: "5G System Enhancements for Edge Computing; Stage 2".

[10] 3GPP TS 32.255: "Telecommunication management; Charging management; 5G Data connectivity domain charging; stage 2"

[11] 3GPP TS 32.290: "Telecommunication management; Charging management; 5G system; Services, operations and procedures of charging using Service Based Interface (SBI)".

[12] 3GPP TS 32.256: "5G connection and mobility domain charging".

[13] 3GPP TS 38.413: "NG Application Protocol (NGAP)".

[14] 3GPP TS 32.257: "Edge computing domain charging".

[15] 3GPP TR 28.815: "Study on charging aspects of edge computing".

# 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].

## 3.2 Symbols

Void.

## 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].

ASP Application Service Provider

DNAI Date Network Access Identifier

EAS Edge Application Server

ECSP Edge Computing Service Provider

SMNO Satellite Mobile network Operator

SSC Satellite Service Customer

SSP Satellite Service Provider

# 4 Background

## 4.1 General

As defined in the TS 22.261 [4], some requirements (e.g. KPIs for a 5G system with satellite access) and support of charging aspects for satellite access and satellite backhaul have been specified. For example, satellites can provide mobile broadband access coverage, they are used by MNOs to provide access for UEs and backhaul service for gNBs in sparsely populated areas (e.g. ocean, forest) and in cases of emergency or temporary measure (e.g. a disaster area).

TR 23.737 [8] studies the 5GS to support satellite access and satellite backhaul which is specified in the TS 23.501 [2], TS 23.502 [3] and TS 23.503 [5]. TR 23.700-28 [7]) supports the discontinuous network coverage to enhance the NR satellite access. They are specified in the TS 23.501 [2], TS 23.502 [3] and TS 23.503 [5].

## 4.2 Satellite access architecture

As described in TR 23.737 [8], there are two main categories of satellite payloads including transparent or re-generative. The implementation of the satellite access architecture can have several forms. The implementation of the transparent satellite is shown in Figure 4.2-1:



Figure 4.2-1: 5GS with transparent satellite enabled NR-RAN

The transparent satellite access network is composed of:

- Satellite enabled UEs, such as IoT devices, broadband vehicular or fixed terminals.

- Satellite is equivalent to a Radio Frequency (RF) Remote Unit, and is full transparent to the New Radio protocols, including the physical layer.

- Remote Radio Unit, including gateways and gNBs.

- 5G CN is accessing these gNBs and DN.

For the case of re-generative mode, the satellite may have some functions of 5GC. One implementation is shown in Figure 4.2-2, where the satellite payload may implement a full gNB supporting a satellite enabled NR-RAN. A Satellite Radio Interface (SRI) transports the N1/N2/N3 interfaces between the on-ground 5G CN and the on-board gNB-CU.



Figure 4.2-2: 5GS with regenerative satellite enabled NR-RAN and on-board gNB

Another implementation in Figure 4.2-3 can note that with a regenerative implementation (either with distributed gNB or not) a 5GS can have a global coverage, providing a single 5G CN with global or regional (continental or sub-continental) coverage as well. The Inter-Satellite Links (ISL) can be used between the satellites.



Figure 4.2-3: 5GS with regenerative satellite enabled NR-RAN, with ISL for regional or global coverage

In the existing 5G satellite access network, the satellite works in transparent mode. The regenerative mode of the satellite will be studied in the future.

## 4.3 Satellite backhaul architecture and functionality

As described in TR 23.737 [8], the architecture for the satellite backhaul is depicted in Figure 4.3-1.



Figure 4.3-1: 5G System with a satellite backhaul

In the existing 5G network with satellite backhaul, the satellite network acts as the transport network between gNB and 5GC.

In Rel-17, in order to imply different packet delivery latency of backhaul connections over satellite network, satellite backhaul category referring to the type of the satellite (i.e. GEO (Geostationary Orbit), MEO (Medium Earth Orbit), LEO (Low Earth Orbit) or OTHERSAT) have been defined in TS 23.501 [2]. In addition, it is assumed that all backhaul connections for a UE are over a single satellite.

In Rel-18, the satellite backhaul may involve multi-hops of ISL (Inter-satellite Link) or multi-types of backhaul connections are over different satellites as shown in the Figure 4.3-2. New satellite backhaul category refers to the type of the satellite (DYNAMIC\_GEO, DYNAMIC \_MEO, DYNAMIC \_LEO, DYNAMIC \_OTHERSAT) has been in TS 23.501 [2]. Only a single backhaul category can be indicated.



Figure 4.3-2: Satellite backhaul via ISL or different satellites

For some deployments, UPF may be deployed on the satellite. In these cases, edge computing or local switch via UPF deployed on the satellite may be performed as specified in TS 23.501 [2].

As described in TR 23.737 [8], in order to enable GEO satellite edge computing in Rel-18, the UPF and Edge Application Servers (EAS) can be deployed on the satellite. The following figure shows the high level architecture of the Satellite Edge Computing via UPF on board.



Figure 4.3-3: Satellite Edge Computing via UPF on-board

As specified in clause 6.2.3.2 of TS 23.548 [9], due to the IP address(es) of the EAS needs to be resolved by the DNS server that is on the ground first, a PDU session with the UPF on the ground needs to be established. Then, according to the EAS Deployment Information as described in clause 6.2.3.4 of TS 23.548 [9], the SMF selects the PSA UPF or UL CL/BP/local PSA on-board based on the DNAI corresponding to the GEO Satellite ID and other factors.

## 4.4 Business roles

Satellite networks in 5G environment involves the services or capabilities may be provided by multiple service providers in the form of following business roles:

- Satellite Mobile Network Operator (SMNO): an operator who can provide satellite communication services for satellite service customer, e.g. 5G MNO.

- Satellite Service Provider (SSP): a Provider who can provide satellite services for SMNO, e.g. satellite companies.

- Satellite Service Customer (SSC): a Communication Service Customer (CSC) who is able to consume satellite communication network, e.g. UE, IoT devices, broadband vehicular or fixed terminals.

Considering the different business models, business roles for satellite networks include (but not limited to):

- End user charging;

- Inter-provider charging.

Depending on the scenarios an organisation can play one or several roles simultaneously, and apply business roles based on corresponding business relationships, e.g.:

- Business roles for SMNO to charge SSC for using satellite communication services.

- Business roles for SSP to charge SMNO for using their satellites.

- When SMNO and SSP role are provided by the same enterprise, to charge SSC role for using their networks and satellite communication services.

In deployments, there could be business scenarios where one or more components are supported by a single enterprise. The present document does not impose any restrictions on the possible deployment scenarios.

# 5 Charging scenarios and key issues

## 5.1 Topic 1: Converged charging for satellite access

### 5.1.1 General description and assumptions

In the satellite access scenario, separate N2 instances are handling separate access type nodes. However, the coverage of the satellite access network may span over the coverage of the terrestrial access network. In order to support the NR satellite, the RAT "NR(LEO)", "NR(MEO)", "NR(GEO)" and "NR(OTHERSAT)" have been specified in 5GC to distinguish the different NR satellite access types in TS 23.501 [2].

Based on the satellite access architecture depicted in clause 4.2, the charging party and charged party can be:

- Charged party: A satellite service customer who using satellite access the gNB.

- Charging party: MNO who charges the satellite service customer for satellite access.

The potential charging requirements for this Use Case is: REQ-CH\_ SATAC\_AC-01.

### 5.1.2 Potential charging requirements

The following are potential high-level charging requirements for satellite in 5GS, derived from the requirements in TS 23.501 [2], and TS 23.502 [3].

**REQ-CH\_ SATAC\_AC-01**: The 5GS should support collecting charging information for satellite access services.

### 5.1.3 Key issues

#### 5.1.3.1 Key issue#1.1: Charging events and charging information required

This key issue is for investigating how to support the satellite access service charging considering REQ-CH\_ SATAC\_AC-01. This investigation covers the following:

- identification of the triggers for charging events for satellite access in the AMF;

- identification and classification of the charging information for satellite access.

#### 5.1.3.2 Key issue #1.2: NF/Service suitable to provide charging information

This key issue is for investigating how to support the satellite access service charging considering REQ-CH\_ SATAC\_AC-01. This investigation covers the following:

- determination of which NF in the 5G system are suitable to provide the charging information to support the satellite access.

### 5.1.4 Possible solutions

#### 5.1.4.1 Solution #1.1: AMF Charging Trigger Function (CTF) based solution for satellite access charging

This solution which relying on CHF/5G Converged Charging System for satellite access charging, addresses the Key Issue#1.1 and Key Issue#1.2.

As specified in TS 23.501 [2], in order to support the NR satellite, the RAT "NR(LEO)", "NR(MEO)", "NR(GEO)" and "NR(OTHERSAT)" have been specified in 5GC to distinguish the different NR satellite access types. The AMF determines the RAT Type based on an indication provided in N2 interface as defined in TS 38.413 [13]. In addition, to ensure that the regulatory requirements are met, the UE location needs to be verified by AMF to enforce that the selected PLMN is allowed to operate in the current UE location.

If a UE is accessing to the network via satellite access, the AMF(CTF) sends the Charging Data Request to CHF for satellite access charging, which has the following charging information enhancements compared with the Figure 5.2.2.2.2.1 in TS 32.256 [12]:

- RAT type extends to include "NR(LEO)", "NR(MEO)", "NR(GEO)" and "NR(OTHERSAT)"

The message flow is similar with the Figure 5.2.2.2.2-1 in TS 32.256 [12]. The Figure 5.1.4.1 -1 describes the high level charging procedure for AMF (CTF) Converged charging for satellite access charging.



Figure 5.1.4.1-1: Registration procedure message flow for satellite access charging --- PEC charging

1. A UE is accessing to the network via satellite access and sends the registration request.
2. The RAN sends N2 message to AMF indicating the type of NR satellite access.
3. For NR satellite access, the AMF may verify the UE location and determine whether the PLMN is allowed to operate at the UE location
4. Registration procedure as described in clause 4.2.2.2.2-1 of TS 23.502 [3].

5. After successful registration, the Registration Accept message is sent to the UE. Optional, if satellite coverage availability information is needed, the AMF(CTF) may obtain the satellite coverage availability information from the OAM.

5ch-a. The AMF sends Charging Data Request [Event] including the enhancement of RAT type to CHF for the UE's successful registration if the AMF determines the NR satellite access and the PLMN is allowed to operate at the UE location.

5ch-b. The CHF creates the CDR.

5ch-c. The CHF acknowledges by sending Charging Data Response [Event] to the AMF.

#### 5.1.4.2 Solution #1.2: AMF for satellite access charging

This solution which relying on CHF/5G Converged Charging System for satellite access charging, addresses the Key Issue#1.1.

As specified in TS 23.501 [2] clauses 5.4.10 and 5.4.11, when UE is accessing to the network via satellite access, AMF determines the RAT type for NR satellite access, i.e. NR(LEO), NR(MEO), NR(GEO) and NR(OTHERSAT), and provides the indication of RAT type in the N2 interface.

In addition, the serving PLMN can enforce mobility restrictions for NR satellite access. N2 connection may be released with cause value indicating that the UE is not in the PLMN serving area. The AMF may initiate deregistration of the UE when an N2 UE Context Release Request is received with cause value indicating that the UE is not in PLMN serving area, as specified in TS 38.413 [13].

The AMF reports charging information to CHF about 5G network connection via satellite access, during three chargeable events:

* Service request (Start of N2 connection)
* Service release (End of N2 connection)
* De-registration (End of N2 connection with the cause value "UE not in PLMN serving area")

The service request message flow for satellite access charging, for PEC scenario as example, is shown in Figure 5.1.4.2-1. The message flow is similar to Figure 5.2.2.3.2.1 in TS 32.256 [12], with two enhancements:

* For NR satellite access, the AMF may decide to verify the UE location and determine whether the PLMN is allowed to operate at the UE location, as described in clause 5.4.11.4 of TS 23.501 [2].
* The AMF determines the RAT Type for NR satellite access, i.e. NR(LEO), NR(MEO), NR(GEO) and NR(OTHERSAT)

The service release message flow for satellite access charging is the same as Figure 5.2.2.3.4.1 in TS 32.256 [12].

The de-registration message flow for satellite access charging is described in the same as Figure 5.2.2.2.8.2 in TS 32.256 [12]. with a key difference:

* The AMF may deregister the UE when the UE context release request has the cause value specified as "UE not in PLMN serving area".



Figure 5.1.4.2-1: Service request message flow for satellite access charging --- PEC charging

1. Service request procedure initiated by UE, accessing to the network via satellite access.

2. The (R)AN sends N2 message to AMF, indicating the type of NR satellite access. For NR satellite access, the AMF may decide to verify the UE location and determine whether the PLMN is allowed to operate at the UE location, as described in clause 5.4.11.4 of TS 23.501 [2].

3. The AMF determines the RAT type for NR satellite access, i.e. NR(LEO), NR(MEO), NR(GEO) and NR(OTHERSAT).

4. Service request procedure continuation, described in step 3-11 in Figure 4.2.3.2-1 of TS 23.502 [3].

5. The AMF sends N2 request to (R)AN, indicating the RAT type for NR satellite access

6. Connection resource setups

7. The (R)AN sends N2 request Ack to AMF

8ch-a. The AMF sends Charging Data Request [Event] to CHF for the N2 connection established for the UE, triggered by the "Start of N2 connection" trigger, defined in Table 5.2.1.2.1.1 TS 32.256 [12].

8ch-b. The CHF creates the CDR for this N2 connection establishment.

8ch-c. The CHF acknowledges by sending Charging Data Response [Event] to the AMF.

9. Service request procedure continuation, described in step 15-22 in Figure 4.2.3.2-1 of TS 23.502 [3].



Figure 5.1.4.2-2: Deregistration message flow for satellite access charging --- PEC charging

1. Release initiated by the (R)AN. The (R)AN determines whether the UE is moving outside the PLMN serving area, based on the mobility restrictions for NR satellite access enforced by the serving PLMN. If the UE is outside the PLMN serving area, the N2 Context Release Request cause indicates the release is requested due to a UE using satellite access moved out of PLMN serving area with the case value specified as "UE not in PLMN serving area". As defined in TS 38.413 [13] Clause 9.3.1.2, the NAS cause "UE not in PLMN serving area" means that the release is due to the UE not being within the serving area of its current PLMN (for NTN).

2. If the UE is not in PLMN serving area, the AMF may deregister the UE as described in TS 23.502 [3] clause 4.2.2.3.3 before continuing with the AN Release procedure.

3ch-a. The AMF sends Charging Data Request [Event] to CHF for the UE successful deregistration, triggered by the "Deregistration" trigger, defined in Table 5.2.1.2.1.1 TS 32.256 [12].

3ch-b. The CHF creates the CDR for this deregistration.

3ch-c. The CHF acknowledges by sending Charging Data Response [Event] to the AMF.

4. Deregistration procedures, described in step 3-5 in Figure 4.2.2.3.3-1 TS 23.502 [3].

#### 5.1.4.3 Solution #1.3: SMF Charging Trigger Function (CTF) based solution for satellite access charging

This solution which relying on CHF/5G Converged Charging System for satellite access charging, addresses the Key Issue#1.1 and Key Issue#1.2.

In order to support the charging of data connectivity via satellite access, SMF needs to determine the service data flow accessed by the satellite and collects satellite access charging information. Therefore, the SMF(CTF) sends the Charging Data Request to CHF for the PDU session charging, which has the following charging information enhancements compared with the Table 6.2.1.2.1 in TS 32.255 [10]:

* RAT type extends to include "NR(LEO)", "NR(MEO)", "NR(GEO)" and "NR(OTHERSAT)"

The message flow is similar to the message flows for PDU session establishment, modification and release in clause 5.2.2.2 in TS 32.255 [10].

### 5.1.5 Evaluation

#### 5.1.5.1 Solutions evaluation for Key issue #1.1

Both solutions #1.1 addresses Key issue #1.1, for the registration procedure message flow regarding 5G connection via satellite access, with the same charging information. The enhancement of the charging information (e.g. RAT type) is required.

Solutions #1.2 addresses Key issue #1.1, for the service request, service release and De-registration message flow regarding 5G connection via satellite access. The enhancement of the charging information (e.g. RAT type) is required.

Solution #1.3 addresses Key issue #1.1 using SMF to provide the charging information, regarding 5G data connectivity via satellite access. Solution #1.3 proposes to enhance the charging information (e.g. RAT type).

#### 5.1.5.2 Solutions evaluation for Key issue #1.2

Both solutions #1.1 and #1.2 address Key issue #1.2, regarding 5G connection via satellite access, with the same NF that is responsible for the interaction with CHF. Both solution use AMF to provide the charging information and has no impact on the AMF charging architecture or operation.

Solution #1.3 addresses Key issue #1.1 using SMF to provide the charging information, regarding 5G data connectivity via satellite access.

### 5.1.6 Conclusion

It is concluded that the solutions #1.1, #1.2 and #1.3 are the feasible solutions and new parameters need to be added for the satellite access charging.

## 5.2 Topic 2: Converged charging for satellite backhaul

### 5.2.1 General description and assumptions

#### 5.2.10 Introduction

In the satellite backhaul scenario, multiple satellite backhaul categories referring to the type of the satellites have been introduced in clause 4.3.

#### 5.2.1.1 Use Case #2.1: MNO charging subscriber based on monitored QoS

This use case focuses on SSC, MNO and Satellite Provider business roles.

A SSC has a subscription with the MNO which allows usage of 5GS for satellite backhaul. The MNO can provide different QoS (e.g. delay) to the SSC because of the different satellite backhaul categories.

For this case, the charging party and charged party can be:

- Charged party: SSC access a gNB which is using satellite backhaul link to CN which is consuming a service available from MNO.

- Charging party: MNO who provides the satellite communication service to the SSC, and the Satellite Service Provider who provides the satellite to MNO.

The SSC can be charged, either by the MNO or Satellite Provider, on QoS whilst the service is being consumed via satellite.

The potential charging requirements for this Use Case are: REQ-CH\_ SATBH\_DC-01 and REQ-CH\_ SATBH\_DC-02.

#### 5.2.1.1 Use Case #2.2: MNO charged by satellite provider based on usage

This use case focuses on MNO and Satellite Provider business roles.

The MNO has an agreement to use the satellite from satellite provider, the charging party and charged party can be:

- Charged party: MNO who using the satellite from the Satellite Service Provider

- Charging party: Satellite Service Provider who provides the satellite to MNO

The inter-provider charging by MNO could be based on the total data volume transferred via the satellite.

The potential charging requirements for this Use Case is: REQ-CH\_ SATBH\_DC-01 and REQ-CH\_ SATBH\_DC-02.

### 5.2.2 Potential charging requirements

The following are potential high-level charging requirements for satellite in 5GS, derived from the requirements in TS 23.501 [2], TS 23.502 [3] and TS 23.503 [5].

**REQ-CH\_ SATBH\_DC-01**: The 5GS should support collecting charging information related to satellite backhaul service.

**REQ-CH\_ SATBH\_DC-02:** The 5G system should support charging information reporting for satellite backhaul service based on the following criteria:

- Monitored QoS in terms of packet delay (see TS 23.501 [2]).

### 5.2.3 Key issues

#### 5.2.3.1 Key issue #2.1: Charging events and charging information required

This key issue is for investigating how to support the satellite backhaul service charging considering REQ-CH\_ SATBH\_DC-01 and REQ-CH\_ SATBH\_DC-02. This investigation covers the following:

- identification of the triggers for charging events for satellite backhaul;

- identification and classification of the charging information for satellite backhaul;

- evaluation QoS Flow Based Charging is applicable for satellite backhaul.

#### 5.2.3.2 Key issue #2.2: NF/Service suitable to provide charging information

This key issue is for investigating how to support the satellite backhaul service charging considering REQ-CH\_ SATBH\_DC-01 and REQ-CH\_ SATBH\_DC-02. This investigation covers the following:

- determination of which NF in the 5G system are suitable to provide the charging information to support the satellite backhaul.

### 5.2.4 Possible solutions

#### 5.2.4.1 Solution #2.1: SMF Charging Trigger Function (CTF) based solution for satellite backhaul charging

##### 5.2.4.1.1 General description

This solution which relying on CHF/5G Converged Charging System for satellite backhaul charging, addresses the Key Issue#2.1 and Key Issue#2.2.

As specified in TS 23.502 [3], during the PDU Session establishment procedure, if the AMF is aware that a satellite backhaul is used towards 5G AN, the AMF may report this to SMF. If AMF is aware that satellite backhaul category changes (e.g. at handover), the AMF reports the current satellite backhaul category and indicates the satellite backhaul category change to SMF.

If dynamic satellite backhaul is used, i.e. capabilities (latency and/or bandwidth) of the satellite backhaul change over time due to e.g. use of varying inter-satellite links as part of backhaul, the AMF notifies the SMF of the corresponding dynamic satellite backhaul category to serve the PDU Session. Then, the SMF informs this to PCF. The PCF may trigger QoS monitoring as specified in TS 23.501 [2]. The QoS monitoring can be used to measure packet delay between UE and PSA UPF.

Since the SMF obtains the satellite backhaul categories or satellite backhaul category changes (e.g. at handover) from the AMF, the SMF can be used to provide the charging information to support the satellite backhaul charging.

The charging trigger conditions in SMF in TS 32.255 [10] have the following enhancements:

Table 5.2.4.1.1-1: Extend to Default Trigger conditions in SMF for Satellite Backhaul   
(3GPP TS 32.255 [10] – Table 5.2.1.4.1)

| Trigger Conditions | Trigger level | Converged Charging default category | Offline only charging default category | CHF allowed to change category | CHF allowed to enable and disable | Message when "immediate reporting" category |
| --- | --- | --- | --- | --- | --- | --- |
| Satellite backhaul category change | PDU session | Deferred | Deferred | Yes | Yes |  |
| Satellite Backhaul QoS | PDU session | Deferred | Deferred | Yes | Yes |  |

##### 5.2.4.1.2 Architecture description

The converged charging architecture for SMF Charging Trigger Function (CTF) based solution as depicted in Figure 5.2.4.1.2-1. SMF based solution-CTF and are proposed for the session based charging.



Figure 5.2.4.1.2-1: 5G data connectivity converged charging architecture defined in TS 32.255 [10]

##### 5.2.4.1.3 Charging procedures for satellite backhaul

The Figure 5.2.4.1.3-1 describes the high level charging procedure for SMF (CTF) Converged charging for satellite backhaul charging.



Figure 5.2.4.1.3-2: Message flow for satellite backhaul charging

1. SMF received the PDU session establishment request including satellite backhaul category as specified in clause 4.3.2.2 TS 23.502 [3].

1ch-a. The SMF sends Charging Data Request [Initial, Requested Quota] including satellite backhaul category and satellite backhaul usage report to CHF for the satellite backhaul charging.

1ch-b. The CHF creates a CDR.

1ch-c. The CHF acknowledges by sending Charging Data Response [Initial, Granted Quota] to the SMF.

1ch-d: Granted Units Supervision: The SMF monitors the consumption of the granted units and the delivered QoS if the monitored QoS result for dynamic satellite backhaul is requested for charging.

2. SMF sends the satellite backhaul usage report request to UPF during N4 Session Establishment/Modification procedure, if the SMF obtains the satellite backhaul category or satellite backhaul category changes from AMF.

3. UPF starts QFI related to the satellite backhaul counts and detects an event that the satellite backhaul usage report has to be reported.

4. UPF/PSA UPF reports the satellite backhaul usage report to SMF.

4ch-a. The SMF sends Charging Data Request[Update, Requested Quota] including the satellite backhaul usage report and the corresponding current satellite backhaul category to the CHF. The update of Charging Data Request can also be triggered by satellite backhaul category changes. If the dynamic satellite backhaul is obtained by the SMF, Charging Data Request needs to include the Satellite Backhaul QoS(e.g. throughput, latency, jitter, error rate).

4ch-b. The CHF update a CDR.

4ch-c. The CHF acknowledges by sending Charging Data Response [Update, Granted Quota] to the SMF.

5. SMF sends the granted quotas to the UPF/PSA UPF in the usage reporting response.

6. UPF/PSA UPF reports the usage reporting of the last satellite backhaul traffic to SMF.

6ch-a. The SMF sends Charging Data Request [Termination, Used Units] to CHF including the satellite backhaul traffic usage report and the corresponding current satellite backhaul category.

6ch-b. The CHF close a CDR.

6ch-c. The CHF acknowledges by sending Charging Data Response [Termination] to the SMF.

7. SMF sends the usage reporting response to the UPF/PSA UPF.

##### 5.2.4.1.4 CDR Information Structure with Satellite Backhaul information

The Table 2 provides the information structure, as described in 3GPP TS 32.290 [11] which includes the attributes that are used for Satellite Backhaul.

Table 5.2.4.1.4-2: Extend to Common Data structure of Charging Data Request with Satellite Backhaul Identification(3GPP TS 32.290 [11] – Table 7.1)

| **Information Element** | **Converged Charging**  **Category** | **Offline Only Charging Category** | **Description** |
| --- | --- | --- | --- |
| Satellite Backhaul Information | OC | - | This field contain parameters that can be used to determine that a Satellite Backhaul has been used for the data traffic |
| Satellite Backhaul Category | OC | - | Field contains the type of the satellite (i.e. GEO, MEO, LEO or OTHERSAT, DYNAMIC\_GEO, DYNAMIC \_MEO, DYNAMIC \_LEO, DYNAMIC \_OTHERSAT) used in the backhaul |
| Satellite Backhaul QoS | OC | - | This field may be added optionally as a further enhancement to contain the result of the calculation of the following attributes (throughput), latency, jitter, and error rate) |
| Satellite backhaul usage report | OC | - | This field holds the amount of the total volumes for the current satellite backhaul category. |

### 5.2.5 Evaluation

#### 5.2.5.1 Solutions evaluation for Key issue #2.1

Solution #2.1 addresses Key issue #2.1 with no impact on the SMF charging architecture, operation. New parameters(e.g. Satellite Backhaul Information) for satellite backhaul charging are required.

#### 5.2.5.2 Solutions evaluation for Key issue #2.2

Solution #2.1 addresses Key issue #2.2 using the SMF in the 5G system to provide the charging information to support the satellite backhaul.

### 5.2.6 Conclusion

It is concluded that the solution #2.1 is the feasible solution and new parameters and triggers need to be added for the satellite backhaul charging.

## 5.3 Topic 3: Charging for Edge Computing with satellite backhaul

### 5.3.1 General description and assumptions

#### 5.3.1.0 Relationship between Edge Computing and satellite backhaul

As specified in TS 23.501 [2], the Edge Computing is deployed with UPF and Edge Computing services on-board the satellite. The following figure shows the high level architecture of the Satellite Edge Computing with satellite backhaul. The Edge Computing Service Provider (ECSP) provides the infrastructure resources used by the ASP and by SMNO to enable them to host their Edge applications close to the users. The Satellite Service Provider (SSP) can act as ECSP to provide the satellite infrastructure resources to the ASP and SMNO to enable them to host their Edge applications close to the SSC. The relationship between the ASP and SMNO is the same as the normal edge computing case.



Figure 5.3.1-1: The relationship between Edge Computing and satellite backhaul

#### 5.3.1.1 Use Case #3.1: Satellite Service Provider charging Application Service Provider based on usage

Satellite Service Provider provides the satellite infrastructure resources to ASP to enable the EAS to be running on the satellite.

Satellite Service Provider may charge ASP for the infrastructure resources usage to enable and support the EAS(s) on the satellite.

This inter-provider charging may be based on the infrastructure resources actually used by the EAS(s).

#### 5.3.1.2 Use Case #3.2: SMNO charging subscriber for accessing satellite edge application

A SSC has a subscription with the SMNO which allows usage of 5GS for accessing satellite edge applications.

5GS provides the UPF deployed on satellite to support satellite edge computing. The UPF deployed on satellite can act as UL CL/BP/local PSA UPF or act as PSA UPF.

The MNO may charge these 5GS capabilities in the following ways:

- Charge the individual subscribers for using the 5G capabilities to access satellite edge applications.

The End user charging by MNO could be based on monitored QoS for the satellite edge application.

### 5.3.2 Potential charging requirements

#### 5.3.2.1 Potential requirements for inter-provider based charging

**REQ-CH\_ SATBH\_EC-01**: The charging mechanism for 5G system should support collecting charging information on usage of satellite backhaul per EAS.

#### 5.3.2.2 Potential requirements for subscriber based charging

**REQ-CH\_ SATBH\_EC-02:** The 5G system should support collecting charging information per SSC on usage of satellite edge application.

### 5.3.3 Key issues

#### 5.3.3.1 Key issue #3.1: Charging events and charging information required

This key issue is for investigating how to support **REQ-CH\_ SATBH\_EC-01** and **REQ-CH\_ SATBH\_EC-02**. This investigation covers the following:

- determination of which NFs in the 5G system are suitable to provide the charging information to support the Edge Computing with satellite backhaul;

- identification of the triggers for charging events for Edge Computing with satellite backhaul;

- identification and classification of the charging information for Edge Computing with satellite backhaul.

### 5.3.4 Possible solutions

#### 5.3.4.1 Solution #3.1: Possible solutions for SMNO charging subscriber for accessing satellite edge application

##### 5.3.4.1.1 General description

This solution which relying on CHF/5G Converged Charging System for Edge Computing charging with satellite backhaul, addresses the Key Issue#3.1.

As specified in TS 23.501 [2], the SMF is locally configured with mapping relationship between Date Network Access Identifier (DNAI) and GEO Satellite ID and determines DNAI based on local configuration, DNN or S-NSSAI or both and the GEO Satellite ID received from AMF. If the UE is allowed to access the service(s) according to the EAS Deployment Information as described in clause 6.2.3.4 of TS 23.548 [9], the SMF selects the PSA UPF or UL CL/BP/local PSA based on DNAI corresponding to the GEO satellite ID and other factors. If the GEO satellite ID changes, the AMF may update the latest GEO Satellite ID to the SMF.

Since the SMF may obtain GEO satellite backhaul category and GEO satellite ID from the AMF and select the UPF on-board to enable the UE accesses the EAS on-board, the SMF(CTF) can be used to provide the charging information to support the Edge Computing charging with satellite backhaul.

If the SMF obtains the GEO satellite backhaul category and GEO Satellite ID from the AMF, the SMF(CTF) sends the Charging Data Request to CHF for Edge Computing charging with satellite backhaul, which adds the following satellite backhaul charging information:

Table 5.3.4.1.1-1: Extend to Common Structure of PDU Session Charging Information for Edge Computing charging with satellite backhaul (3GPP TS 32.255 [10] –Table 6.2.1.2.1)

| **Information Element** | **Category** | **Description** |
| --- | --- | --- |
| Satellite Backhaul Information | OC | This field contain parameters that can be used to determine that a Satellite Backhaul has been used for the data traffic |
| Satellite Backhaul Category | OC | Field contains the type of the satellite (i.e. GEO) used in the backhaul |
| GEO Satellite ID | OC | This field contains the ID of the GEO satellite |
| Satellite Backhaul QoS | OC | This field may be added optionally as a further enhancement to contain the result of the calculation of the following attributes (throughput), latency, jitter, and error rate) |

The charging trigger conditions in SMF in TS 32.255 [10] have the following enhancements:

Table 5.3.4.1.1-2: Extend to Default Trigger conditions in SMF for edge computing Satellite Backhaul (3GPP TS 32.255 [10] – Table 5.2.1.4.1)

| Trigger Conditions | Trigger level | Converged Charging default category | Offline only charging default category | CHF allowed to change category | CHF allowed to enable and disable | Message when "immediate reporting" category |
| --- | --- | --- | --- | --- | --- | --- |
| GEO satellite ID change | PDU session | Deferred | Deferred | Yes | Yes |  |

##### 5.3.4.1.2 Charging procedures for subscriber based edge computing charging with satellite backhaul

The message flow is based on the charging principles for 5GS usage for Edge Computing specified in clause 5.1.2 of the 3GPP TS 32.257 [14] with the enhancement of the satellite backhaul information for the PDU session charging information. The Figure 5.3.4.1.2-1 describes the high level charging procedure for SMF (CTF) Converged charging for edge computing charging with satellite backhaul.



Figure 5.3.4.1.2-1: Message flow for edge computing charging with satellite backhaul

1. UE starts using a satellite edge application.
2. Charging Data Request [Initial]: the SMF sends the request including satellite backhaul charging information (e.g. GEO satellite backhaul category, GEO Satellite ID) to the CHF to reserve a number of units if it obtains the GEO satellite backhaul category and GEO Satellite ID from the AMF.
3. Open CDR: based on policies, the CHF opens a CDR related to the service for edge application.
4. Charging Data Response [Initial]: the CHF sends response to SMF.
5. UE edge application usage ongoing.
6. Charging Data Request [Update, Usage Reporting]: the SMF sends the request including the satellite backhaul charging information (e.g. GEO satellite backhaul category, GEO Satellite ID) to the CHF. The update of Charging Data Request can also be triggered by GEO satellite ID changes. If the dynamic satellite backhaul is obtained by the SMF, Charging Data Request needs to include the Satellite Backhaul QoS(e.g. throughput, latency, jitter, error rate).
7. Update CDR: based on policies, the CHF updates the CDR with charging data related to the service.
8. Charging Data Response [Update]: The CHF sends response to SMF.
9. Service delivery ongoing: the NF (CTF) continues to deliver the service.
10. UE stops using the edge application: the SMF is requested to end the service delivery and does this.
11. Charging Data Request [Termination]: the SMF sends the request to the CHF including satellite backhaul information, for charging data related to the service termination.
12. Close CDR: based on policies, the CHF closes the CDR with charging data related to the service termination.
13. Charging Data Response [Termination]: The CHF informs the SMF on the result of the request.

#### 5.3.4.2 Solution #3.2: Possible solutions for EAS on-board deployment charging

##### 5.3.4.2.1 General description

This solution which relying on CHF/5G Converged Charging System for EAS on-board deployment charging for Edge Computing charging with satellite backhaul, addresses the Key Issue#3.1.

The possible charging architectures are the same as clause 7.3.4 of TR 28.815 [15]. In these architectures, it is assumed that the MnS producer, CHF, CEF and Billing Domain are owned by the same SSP (ECSP). The charging for EAS on-board deployment could be supported with CEF to enable the charging for MnS producer.

Since the edge computing via the satellite backhaul only using GEO satellite backhaul category in this release, the SSP itself has the knowledge of all the satellite information, therefore, the EAS deployment charging information needs to add the satellite backhaul information:

Table 5.3.4.2.1-1: Extend to Structure of EAS Deployment Charging Information   
(3GPP TS 32.257 [14] –Table 6.2.2.1.2-1)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Information Element | | Category | | Description | |
| Satellite backhaul information | | OC | | This field contain parameters that can be used to determine that a Satellite Backhaul has been used for the data traffic. | |
| Satellite backhaul category | | OC | | This field contains the type of the satellite (i.e. GEO) used in the backhaul. | |
| GEO Satellite ID | | OC | | This field contains the ID of the GEO satellite. | |

##### 5.3.4.2.2 Charging procedures for EAS on-board deployment charging

The message flow is similar with the Figure 5.2.3.2 in TS 32.257 [14] with the enhancement of the EAS Deployment Charging Information. Figure 5.3.4.2.2-1 describes the high level of EAS on-board deployment charging message flows in PEC, based on the converged charging architecture with MnS producer enabled by CEF.



Figure 5.3.4.2.2-1: EAS deployment charging - PEC

1. CEF subscribes to the notifications about EAS LCM from the MnS.
2. The MnS consumer sends the EAS LCM request to the MnS producer.
3. EAS LCM process: The MnS producer processes and executes the EAS LCM according to the request (e.g. instantiation, upgrade, deletion).
4. EAS LCM response: The MnS producer sends the EAS LCM result to the MnS consumer.
5. EAS LCM notification: The MnS producer sends the EAS LCM notification to the CEF:

5ch-a) Charging Data Request [Event]: The CEF generates charging data related to the EAS LCM notification and sends the charging data request including the satellite backhaul information(e.g. GEO satellite backhaul category, GEO Satellite ID).

5ch-b) Create CDR: The CHF stores received information and create a CDR related to the event.

5ch-c) Charging Data Response [Event]: The CHF informs the CEF on the result of the request.

### 5.3.5 Evaluation

#### 5.3.5.1 Solutions evaluation for Key issue #3.1

Solutions #3.1 addresses Key issue #3.1. The solution uses SMF to provide the charging information for SMNO charging subscriber for accessing satellite edge application. The enhancement of the PDU session charging information (i.e. Satellite Backhaul Information) and new charging trigger conditions are required.

Solutions #3.2 addresses Key issue #3.1. The solution supports the EAS on-board deployment charging. The enhancement of the EAS Deployment charging information (i.e. Satellite Backhaul Information) is required.

### 5.3.6 Conclusion

It is concluded that the solution #3.1 and solution #3.2 are the feasible solutions and new parameters and triggers need to be added for the edge computing charging with satellite backhaul.

## 5.4 Topic 4: Charging for SSC-to-SSC communications via satellite

### 5.4.1 General description and assumptions

### 5.4.1.0 Introduction

As specified in TS 23.501 [2], the SSC-to-SSC communications can be locally routed by UPF(s) deployed on satellite (i.e. through local switch) to the target SSC without traversing back to the satellite gateway on the ground. The Local switching via UPF(s) deployed on satellite only applies on GEO satellite backhaul case and considers only DNNs and slices for 5G VN. The UPF deployed on satellite can act as UL CL/BP/local PSA UPF or act as PSA UPF. This case only supports for unicast traffic forwarding of a 5G VN in this release. The following figure shows the high level architecture of the SSC-to-SSC communications via satellite.



Figure 5.4.1-1: Local Data Switching via a UPF on-board



Figure 5.4.1-2: Local Data Switching via multiple UPFs on-board

#### 5.4.1.1 Use Case #4.1: MNO charging subscribers for accessing 5G VN group on usage of satellite

The VN group communication type(e.g. N6 based/N19-based/Local switch) can be supported by the UPF (s) deployed on satellite. The consumptions of network traffic in operator are different in three types of traffic forwarding methods. For Local switch, the traffic is locally forwarded by a single UPF on the satellite. N19 tunnel may be established between two UPFs deployed on different satellites for traffic between SSCs. Also, N6 may be used for carrying traffic between UPFs deployed on different satellites.

The subscribers can be charged by MNO based on the VN group communication type (e.g. N6 based/N19-based/Local switch) and volume via the satellite.

### 5.4.2 Potential charging requirements

The following are potential high-level charging requirements for subscriber based charging:

**REQ-CH\_ SATBH\_VN-01**: The charging mechanism for 5G system should support collecting charging information on usage of satellite for 5G VN group related to the data volume.

### 5.4.3 Key issues

#### 5.4.3.1 Key issue #4.1: Charging events and charging information required

This key issue is for investigating how to support **REQ-CH\_ SATBH\_VN-01** and **REQ-CH\_ SATBH\_VN-02**. This investigation covers the following:

- identification and classification of the charging event for SSC-to-SSC communications via satellite;

- identification and classification of the charging information for SSC-to-SSC communications via satellite.

### 5.4.4 Possible solutions

#### 5.4.4.1 Solution #4.1: SMF Charging Trigger Function (CTF) based solution for 5G VN over satellite backhaul

##### 5.4.4.1.1 General description

This solution which relying on CHF/5G Converged Charging System for satellite backhaul charging, addresses the Key Issue#4.1.

As specified in TS 23.501 [2], local switching via UPF(s) deployed on satellite only applies on GEO satellite backhaul case and considers only DNNs and slices for 5G VN. As specified in TS 23.502 [3], if the AMF is aware that the UE is accessing over a gNB using GEO satellite backhaul, it sends the GEO satellite ID to the SMF.

As specified in TS 23.501 [2], N19 tunnel may be established between two UPFs deployed on different satellites for traffic between UEs. Also, N6 may be used for carrying traffic between UPFs deployed on different satellites. Only a single SMF is supported for local switching and N19 forwarding, i.e. both UEs are served by the same SMF. The SMF needs to determine the UEs are served by GEO satellites deploying UPFs and connecting to each other.

The SMF is locally configured with mapping relationship between DNAI and GEO Satellite ID and selects the UPF deployed on satellite acting as UL CL/BP/(local) PSA UPF according to the DNAI. Therefore, the SMF (CTF) can be used to provide the charging information to support SSC-to-SSC communications via satellite backhaul. The Charging Data Request adds the following satellite backhaul charging information for the SSC-to-SSC communications PDU session:

Table 5.4.4.1-1: Extend to Common Structure of PDU Session Charging Information for 5G VN charging over satellite backhaul (3GPP TS 32.255 [10] –Table 6.2.1.2.1)

| **Information Element** | **Category** | **Description** |
| --- | --- | --- |
| Satellite Backhaul Information | OC | This field contain parameters that can be used to determine that a Satellite Backhaul has been used for the data traffic. |
| Satellite Backhaul Category | OC | Field contains the type of the satellite (i.e. GEO) used in the backhaul. |
| GEO Satellite ID | OC | This field contains the ID of the GEO satellite |
| Satellite Backhaul QoS | OC | This field may be added optionally as a further enhancement to contain the result of the calculation of the following attributes (throughput), latency, jitter, and error rate). |
| Satellite backhaul usage report | OC | This field holds the amount of the total volumes for the current satellite backhaul category. |

The charging trigger conditions in SMF in TS 32.255 [10] have the following enhancements:

Table 5.4.4.1.1-2: Extend to Default Trigger conditions in SMF for 5G VN charging over satellite backhaul (3GPP TS 32.255 [10] – Table 5.2.1.4.1)

| Trigger Conditions | Trigger level | Converged Charging default category | Offline only charging default category | CHF allowed to change category | CHF allowed to enable and disable | Message when "immediate reporting" category |
| --- | --- | --- | --- | --- | --- | --- |
| GEO satellite ID change | PDU session | Deferred | Deferred | Yes | Yes |  |

##### 5.4.4.1.2 Charging procedures for SSC-to-SSC communications via satellite backhaul

The message flow is similar as the message flows for PDU session establishment, modification and release in clause 5.2.2.2 in TS 32.255 [10]. The Figure 5.4.4.1.2-1 describes the high level charging procedure for SMF (CTF) Converged charging for SSC-to-SSC communications charging via satellite backhaul.



Figure 5.4.4.1.2-1: Message flow for SSC-to-SSC communications charging via satellite backhaul

1. SMF received the PDU session establishment request including GEO satellite backhaul category and GEO Satellite ID as specified in clause 4.3.2.2 TS 23.502 [3]. The SMF determines the UEs are in a 5G VN group. If the UEs are served by a UPF on-board, local switching is used. If SMF determines the UEs are served by GEO satellite(s) deploying UPFs and connecting to each other, the N6 based/N19-based VN group communication type may be used.

1ch-a. The SMF sends Charging Data Request [Initial, Requested Quota] including satellite backhaul charging information (e.g. GEO satellite backhaul category, GEO Satellite ID) to CHF.

1ch-b. The CHF creates a CDR.

1ch-c. The CHF acknowledges by sending Charging Data Response [Initial, Granted Quota] to the SMF.

2. SMF sends the PDU session establishment response.

3. The traffic is forwarded between UEs in the 5G VN group as the request.

4. UPF/PSA UPF on-board reports the usage reporting to SMF.

4ch-a. The SMF sends Charging Data Request [Update, Used Quota and Requested Quota] including satellite backhaul charging information to CHF. The update of Charging Data Request can also be triggered by GEO satellite ID changes. If the dynamic satellite backhaul is obtained by the SMF, Charging Data Request needs to include the Satellite Backhaul QoS(e.g. throughput, latency, jitter, error rate).

4ch-b. The CHF update a CDR.

4ch-c. The CHF acknowledges by sending Charging Data Response [Update, Granted Quota] to the SMF.

5. SMF sends the granted quotas to the UPF/PSA UPF in the usage reporting response.

6. UPF/PSA UPF reports the usage reporting of to SMF.

6ch-a. The SMF sends Charging Data Request [Termination, Used Units] including satellite backhaul charging information to CHF.

6ch-b. The CHF closes a CDR.

6ch-c. The CHF acknowledges by sending Charging Data Response [Termination] to the SMF.

7. SMF sends the usage reporting response to the UPF/PSA UPF.

### 5.4.5 Evaluation

#### 5.4.5.1 Solutions evaluation for Key issue #4.1

Solutions #4.1 addresses Key issue #4.1, using the SMF in the 5G system to provide the charging information to support SSC-to-SSC communications via satellite backhaul, No impact on the SMF charging architecture, operation. New parameters (i.e. Satellite Backhaul Information) and new trigger conditions for 5G VN Group service are required.

### 5.4.6 Conclusion

It is concluded that the solution #4.1 is the feasible solutions and new parameters and triggers need to be added for SSC-to-SSC communications via satellite backhaul.

# 6. Conclusions and Recommendations

The present technical report described the background (see clause 4) including satellite access architecture, satellite backhaul architecture and functionality, and business roles for satellite charging. The present document also identified and documented the use cases and key issues, derived the corresponding potential requirements, and developed and evaluated the possible solutions (see clause 5) for satellite charging. The present document made conclusions on the following aspects:

- Satellite access charging in clause 5.1.6.

- Satellite backhaul charging in clause 5.2.6.

- Edge Computing with satellite backhaul charging, including subscriber charging and inter-provider charging in clause 5.3.6; and

- SSC-to-SSC communications via satellite backhaul charging in clause 5.4.6.

To support converged charging for satellite in normative work, the business relationships (e.g. SSC, SSP, SMNO) need to be specified, as requirements and solutions for the aspects mentioned above. Whether the User location information needs to be extended and alignment with the CT spec, will be addressed during the normative work on satellite access charging.

Annex A (informative):  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2023-02 | SA5#147 | S5-232839 |  |  |  | Initial skeleton | 0.0.0 |
| 2023-03 | SA5#147 | S5-232515  S5-232838 |  |  |  | Add the skeleton to TR 28.844  Add scope and reference to TR 28.844  Some editorial changes including aligning TR front page title with SA5 official title are made as well. | 0.1.0 |
| 2023-04 | SA5#148e | S5-233673  S5-233485  S5-233669  S5-233672  S5-233670 |  |  |  | Introduction of general background and satellite access architecture and functionality  Introduction of satellite backhaul architecture and functionality  Introduction of charging modes  Add charging scenarios and key issues for Satellite access on converged charging for access connection  Add charging scenarios and key issues for Satellite backhaul on converged charging for data connection | 0.2.0 |
| 2023-05 | SA5#149 | S5-234344  S5-234489  S5-234490  S5-234491  S5-234492 |  |  |  | Update Abbreviations and edit correction in business roles  Add charging scenarios and key issues for Edge Computing via satellite backhaul  Add charging scenarios and key issues for SSC-to-SSC communications via satellite  Add solutions for satellite backhaul charging  Satellite backhaul Adding new use case | 0.3.0 |
| 2023-08 | SA5#150 | S5-235890  S5-235892  S5-235891  S5-235894  S5-235893  S5-235895  S5-235896  S5-235897  S5-235898  S5-235899  S5-235662 |  |  |  | Satellite backhaul Key Issue  Add solution on charging for 5G connection via satellite access  Update solutions for satellite backhaul charging  Resolve EN of edge computing charging with satellite backhaul  Add solutions for satellite access charging  Add solutions for edge computing charging with satellite backhaul  Add solutions for SSC-to-SSC communications via satellite backhaul  Add solutions for EAS on-board deployment charging  Add Evaluation for satellite backhaul charging  Add Evaluation and Conclusion for satellite access charging  Add Conclusion for satellite backhaul charging | 0.4.0 |
| 2023-09 | SA#101 | SP-230935 |  |  |  | Presented for information | 1.0.0 |
| 2023-10 | SA5#151 | S5-236996  S5-236997  S5-236494  S5-236999  S5-237000  S5-237001  S5-237002 |  |  |  | Update solutions for edge computing with satellite backhaul  Add Evaluation for edge computing charging with satellite backhaul  Add Conclusion for edge computing charging with satellite backhaul  Update solutions for SSC-to-SSC communications via satellite backhaul  Add Evaluation for SSC-to-SSC communications via satellite backhaul  Add Conclusion for SSC-to-SSC communications via satellite backhaul  Add Conclusion and Recommendations | 1.1.0 |
| 2023-10 |  |  |  |  |  | EditHelp review | 1.1.1 |
| 2023-11 |  | S5-238059 |  |  |  | TR 28.844 Rapporteur cleanup | 1.2.0 |
| 2023-12 | SA#102 | SP-231519 |  |  |  | Presented for approval | 2.0.0 |
| 2023-12 | SA#102 |  |  |  |  | Upgrade to change control version | 18.0.0 |