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| 3GPP TR 23.700-29 V0.1.1 (2023-10) | |
| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on integration of satellite components  in the 5G architecture;  Phase 3  (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 scope of this Technical Report is to study the following aspects of 5GS/EPS integrating of satellite component in Release 19, including:

- Regenerative payload generic architecture:

- Impact to 5GS and EPS to support gNB/eNB onboard the satellite.

- Store and Forward Satellite operation for delay tolerant services:

- The control plane and user plane enhancements if applicable, including the minimum necessary set of Core Network elements to be embedded in the satellite, to support S&F Satellite operation, both for IoT NTN (EPS) and NR NTN (5GS);

- The parameters needed to characterize and support S&F Satellite operation from a delay tolerant services perspective if applicable, both for IoT NTN (EPS) and NR NTN (5GS).

NOTE: S&F for IoT NTN will be studied first and if there is remaining time available NR NTN can then be studied.

- UE-Satellite-UE communication enhancements for 5GS, supporting NR NTN NGSO constellation with and without ISL, with feeder link always available (at least for session establishment):

- Following SA1 requirements, study how at least IMS enablers including mission critical can be supported;

- Minimum necessary set of 5GS network functions onboard the satellite(s) to support such UE-Satellite-UE communication.

# 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 23.503: "Policy and Charging Control Framework for the 5G System".

[5] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[6] 3GPP TS 22.261: "Service requirements for the 5G system; Stage 1".

[7] 3GPP TS 23.682: "Architecture enhancements to facilitate communications with packet data networks and applications".

# 3 Definitions of terms and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 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 TR 21.905 [1].

**serving satellite:** a satellite providing the satellite access to a UE (e.g. providing the serving cell(s)), either for GSO or NGSO. In the case of NGSO, the serving satellite is covering a given geographic area for a limited period of time due to the nature of the orbit.

**S&F Satellite operation:** operation mode providing communication service (in storing and forwarding information) to a UE in periods of time and/or geographical areas in which the serving satellite is not simultaneously connected to the ground network via feeder link or ISL. For the case of UL, "store" refers to on-board storage of UL information from UE and "forward" refers to forwarding of stored UL information to the ground network. For the case of DL, "store" refers to on-board storage of DL information from the ground network and "forward" refers to forwarding of stored DL information to the UE.

**UE-Satellite-UE Communication:** refers to a communication between UEs under the coverage of one or more serving satellites, using satellite access without the user traffic transiting through the ground segment.

NOTE: These definitions are different from those in TS 22.261 [6].

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 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 TR 21.905 [1].

# 4 Architectural Assumptions and Principles

The following architecture assumptions are applied to the study:

- The 5GC architecture for satellite access for NR as defined in TS 23.501 [2] is used as a baseline.

- The EPC architecture for satellite access for IoT as defined in TS 23.401 [5] and the architecture enhancements to facilitate communications with packet data networks and applications as defined in TS 23.682 [7] are used as a baseline.

- At least eNB/gNB is assumed to be on board the satellite.

- Impacts to UE, network functions and entities are minimised. To the extent possible, existing procedures and functionality is reused.

- Inter-Satellite Links (ISL) and Feeder link are assumed to act only as transport layer links and are not specified in 3GPP.

- Store and Forward Satellite Operation assumes that UE-satellite-ground network connectivity can be intermittent as defined in clause 3.1.

- Store and Forward Satellite Operation shall work without ISL.

- NR UE-Satellite-UE communication assumes communication between two or more UEs under the coverage of the same satellite or different satellites.

# 5 Key Issues

## 5.X Key Issue #X: <Key Issue Title>

### 5.X.1 Description

Editor's note: This clause provides a description of the key issue.

# 6 Solutions

## 6.0 Mapping of Solutions to Key Issues

Table 6.0-1: Mapping of Solutions to Key Issues

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| --- | --- | --- | --- | --- |
|  | Key Issues | | | |
| Solutions |  |  |  |  |
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## 6.X Solution #X: <Solution Title>

### 6.X.1 Description

Editor's note: This clause will describe the solution principles and architecture assumptions for corresponding key issue(s). (Sub) clause(s) may be added to capture details.

### 6.X.2 Procedures

Editor's note: This clause describes high-level procedures and information flows for the solution.

### 6.X.3 Impacts to Services, Entities and Interfaces

Editor's note: This clause captures impacts on existing 3GPP nodes and functional elements.

# 7 Overall Evaluation

Editor's note: This clause will provide evaluation of different solutions.

# 8 Conclusions

Editor's note: This clause will list conclusions that have been agreed during the course of the study item activities.

Annex A:  
Example network scenarios for regenerative payload generic architecture (e/gNB on LEO satellite)

The following diagrams are examples of scenarios and situations that the 3GPP standards should handle in order to offer good service to UEs when an eNB/gNB is deployed on a LEO satellite.

These examples are not intended to be an exhaustive set.



Figure A-1: Basic concept of eNB/gNB on LEO satellite



Figure A-2: Handover between satellites with common earth station location

In figure A-2, the UE is basically stationary; the satellite with eNB X is going down in elevation angle, but before X becomes unusable, the satellite with eNB Y rises above the horizon and becomes usable. Again, using methods already discussed in RAN WGs during Release 17/18, the UE can be handed over (e.g. from cell B-a to cell Y-c) during the time that the UE's area is in coverage of both satellites. This handover could be either an X2 or an S1 handover, but note that NB-IoT devices do not support handover.



Figure A-3: Feeder link switch with 2 eNBs/gNBs on LEO satellite

In figure A-3, the UE is basically stationary, but as the satellite flies over, the satellite is moving out of range of one earth station (ES1) and into range of another earth station (ES2). At some time before time T, the satellite system's O&M activates a second eNB (eNB-Z) on the satellite and the S1 interfaces from eNB-Z through ES2 are established at time T. Using methods already discussed in RAN WGs during Release 17/18, the UE can be handed over (e.g. from cell X1-a to cell Z2-b) in the period between time T and time T+k. This handover could be an S1 handover, or, if the eNBs know that they are connected to the same MME, it could be an X2 handover. Note that NB-IoT devices do not support handover.



Figure A-4: Handover between satellites using different earth station location

Figure A-4 is a combination of the preceding scenarios but needs to be supported.

Annex B:  
Store and Forward Satellite operation

The Store and Forward Satellite operation in a 5G system with satellite access is intended to provide some level of communication service for UEs under satellite coverage with intermittent/temporary satellite connectivity (e.g. when the satellite is not connected via a feeder link or via ISL to the ground network) for delay-tolerant communication service.

An example of "S&F Satellite operation" is illustrated in Figure B-1, in contrast to what could be considered the current assumption for the "normal/default Satellite operation" of a 5G system with satellite access.

As shown in Figure B-1:

- Under "normal/default Satellite operation" mode, signalling and data traffic exchange between a UE with satellite access and the remote ground network requires the service and feeder links to be active simultaneously, so that, at the time that the UE interacts over the service link with the satellite, there is a continuous end-to-end connectivity path between the UE, the satellite and the ground network.

- In contrast, under "S&F Satellite operation" mode, the end-to-end exchange of signalling/data traffic is now handled as a combination of two steps not concurrent in time (step A and B in Figure B-1). In step A, signalling/data exchange between the UE and the satellite takes place, without the satellite being simultaneously connected to the ground network (i.e. the satellite is able to operate the service link without an active feeder link connection). In step B, connectivity between the satellite and the ground network is established so that communication between the satellite and the ground network can take place. So, the satellite moves from being connected to the UE in step A to being connected to the ground network in step B.

|  |  |
| --- | --- |
| **"Normal/default Satellite operation" mode** |  |
| **"S&F Satellite operation" mode** |  |

Figure B-1: Illustration of "normal/default operation" and "S&F Satellite operation" modes in a 5G system with satellite access

The concept of "S&F" service is widely used in the fields of delay-tolerant networking and disruption-tolerant networking. In 3GPP context, a service that could be assimilated to an S&F service is SMS, for which there is no need to have an end-to-end connectivity between the end-points (e.g. an end-point can be a UE and the other an application server) but only between the end-points and the SMSC which acts as an intermediate node in charge of storing and relying.

The support of S&F Satellite operation is especially suited for the delivery of delay-tolerant/non-real-time IoT satellite services with NGSO satellites.

Annex C:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Change history | | | | | | | |
| Date | Meeting | TDoc | CR | Rev | Cat | Subject/Comment | New version |
| 2023-10 | SA2#159 | S2-2311913 | - | - | - | Skeleton TR 23.700-29 | 0.0.0 |
| 2023-10 | SA2#159 | S2-2311555 | - | - | - | Example network and satellite configurations for WT1 in FS\_5GSAT\_ARCH\_Ph3 | 0.1.0 |
| 2023-10 | SA2#159 | S2-2311602 | - | - | - | FS\_5GSAT\_ARCH\_Ph3 TR Definitions | 0.1.0 |
| 2023-10 | SA2#159 | S2-2311603 | - | - | - | FS\_5GSAT\_ARCH\_Ph3 TR Scope | 0.1.0 |
| 2023-10 | SA2#159 | S2-2311604 | - | - | - | FS\_5GSAT\_ARCH\_Ph3 Architecture Assumptions | 0.1.0 |