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| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group TSG SA;  Study on Upper layer traffic steer, switch and split over dual 3GPP access  (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 TR is to document use cases, gap analysis and potential service requirements related to 5GS support of enhanced mechanisms for steering, splitting and switching of user data, pertaining to a UE data session, across two 3GPP networks. The following scenarios are covered, where only one single PLMN subscription is assumed:

* Single PLMN;
* PLMN and NPN;
* two PLMNs.

The two 3GPP networks may use same or different RAT, i.e. NR plus NR or E-UTRA, where NR RAT can be terrestrial or satellite NR access (including different staellite orbits, e.g., GEO/MEO/LEO).

For the PLMN plus PLMN / NPN scenarios, the two networks can be managed by the same operator or by different operators (assumed to have a business agreement among them). In both cases, it is assumed that a single PLMN subscription is used to access both networks (including the NPN).

Simultaneous connectivity over two 3GPP networks presumes UE support of proper capabilities (e.g., dual radio).

It is assumed that there are no impacts to normal inter-PLMN roaming scenarios.

Dual subscription scenarios are not in scope of this TR.

# 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] HARAMAIN: Train of the desert (https://www.eltrendeldesierto.com/)

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

[4] 3GPP TS 23.501: "System architecture for the 5G System (5GS)".

# 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 Abbreviations

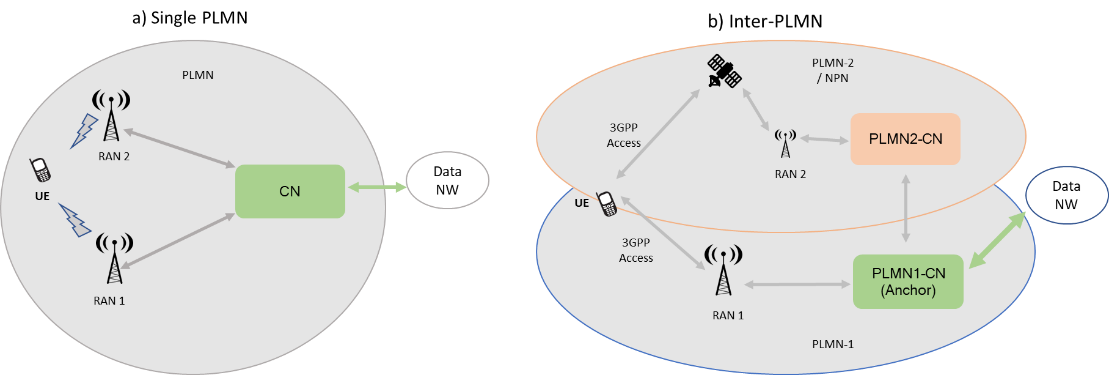
For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

<ABBREVIATION> <Expansion>

# 4 Overview

This TR captures a set of use cases and potential service requirements related to 5G system support of traffic steering, splitting and switching of UE’s user data (pertaining to the same data session), across two 3GPP access networks. Different scenarios are covered: same PLMN, two PLMNs, or between a PLMN and an NPN, solely considering a single PLMN subscription.

The following figure shows two general examples: (a) single PLMN using two terrestrial RAN; (b) traffic across two PLMNs, using terrestrial and satellite access RAN, respectively.



**Figure 4.1: Examples of Intra-PLMN and Inter-PLMN scenarios**

Use cases cover various example combinations of 3GPP access networks using same or different RAT, including terrestrial NR plus NR or NR plus E-UTRA (e.g. using a combined EPC and 5GC), mix of terrestrial plus satellite NR, as well as dual NR satellite access (e.g. using same or different NTN orbits, e.g., GEO/MEO/LEO).

There are also use cases covering connectivity across PLMN and NPN, with one or multiple UEs accessing local NPN services.

In case of inter-PLMN/NPN scenarios, a proper business agreement is assumed to be in place between the two network operators (no impact on normal inter-PLMN roaming), and UE’s user data transferred over the two networks is anchored in the HPLMN core network.

Traffic configuration policies, assumed to be under HPLMN control, can consider different criteria, rules or conditions/restrictions.

Regarding potential new requirements, one general consideration is that they assume 5GS functionalities that do not introduce RAN impacts.

# 5 Use cases

## 5.1 Use case on dual 5G satellite access in maritime scenario

### 5.1.1 Description

This use case describes a scenario where an autonomous ship is remotely controlled from shore. The ship has a UE that is served by two satellite RANs (GEO and LEO) belonging to the same PLMN that is managed by a 5G satellite operator. The ship UE has a single PLMN subscription.

Dual 5G satellite access is applied to accommodate high amount of data traffic for remote control operations. For better performance of the autonomous ship operations, the delay sensitive applications (e.g. remote control operations, collision/accident prevention, emergency management, etc.) use LEO satellite link as it has smaller UE to ground propagation delay than GEO satellite connection (max 30 ms for LEO vs max 280 ms for GEO, TS 22.261 clause 7.4.1). Other applications (i.e. delay tolerant, such as sensor data monitoring, video surveillance, etc.) may use GEO satellite link or aggregate the traffic over both accesses.

### 5.1.2 Pre-conditions

The autonomous ship called as KASS (Korean Autonomous Surface Ship) supports dual 5G satellite access (GEO and LEO).

The UE installed on KASS has a subscription for using GEO and LEO satellite services of a 5G satellite operator.

The UE installed on KASS is registered and connected to GEO and LEO satellites RANs.

Based on the service agreement between the KASS managing company and the 5G satellite operator, the 5G satellite network has the following policies for the UE on KASS:

- The data traffic of delay-sensitive applications is routed via LEO satellite link whenever it is available.

- The data traffic of delay-tolerant applications is aggregated via both LEO and GEO satellite links.

### 5.1.3 Service Flows

1. KASS is in the ocean and is being remotely controlled by the shore control center. KASS has two active data sessions – one for remote control operation and the other for KASS’s sensors data monitoring. As per the agreed policies, the traffic of remote control operation (delay-sensitive) is being routed via LEO satellite link and the traffic of sensors data monitoring (delay-tolerant) is being aggregated via both LEO and GEO satellite links.

Diagram

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Figure 5.1.3-1: Dual 5G satellite access for autonomous ship operations

1. The LEO satellite access becomes unavailable (e.g. due to loss of line of sight between the UE and a satellite). Therefore, all the traffic that was routed via the LEO satellite access is moved to GEO satellite access, while the continuity of data sessions is maintained. The application for ship remote control (delay-sensitive) detects increased communication latency, so it adapts its operations accordingly.

Diagram

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Figure 5.1.3-2: Traffic switching due to loss of connection with LEO satellite access network

1. After a while, the LEO satellite access becomes available again. Therefore, the traffic distribution across two satellite accesses is returned to the state as in Step 1.

### 5.1.4 Post-conditions

The remote shore control centre controlled KASS throughout its route and KASS successfully reached its destination.

### 5.1.5 Existing features partly or fully covering the use case functionality

ATSSS feature specified in TS 23.501 clause 5.32 supports dual user plane connectivity between a UE and a data network using one 3GPP access network and one non-3GPP access network.

From TS 22.261:

Based on operator policy, the 5G system shall be able to dynamically offload part of the traffic (e.g. from 3GPP RAT to non-3GPP access technology), taking into account traffic load and traffic type.

Based on operator policy, the 5G system shall be able to provide simultaneous data transmission via different access technologies (e.g. NR, E-UTRA, non-3GPP), to access one or more 3GPP services.

When a UE is using two or more access technologies simultaneously, the 5G system shall be able to optimally distribute user traffic over select between access technologies in use, taking into account e.g. service, traffic characteristics, radio characteristics, and UE's moving speed.

The 5G system shall support UEs with multiple radio and single radio capabilities.

The 5G system shall be able to provide services using satellite access.

A 5G system with satellite access shall support different configurations where the radio access network is either a satellite NG-RAN or a non-3GPP satellite access network, or both.

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

[PR 5.1.6-001] The 5G System shall support a mechanism to steer, split, and switch the user plane traffic over two 5G satellite access networks belonging to the same PLMN, where the user plane traffic is anchored in the 5GC.

## 5.2 Use case on Inter PLMN Mobility Scenario

### 5.2.1 Description

Consider an MNO A, offering specific mobile services in targeted areas with a small contiguous footprint. MNO A has an existing business agreement with MNO B (an operator with relatively larger contiguous footprint) which allows MNO A subscribers to roam on MNO B network when MNO A subscribers are outside its own coverage footprint.

When inside the coverage footprint of both MNO A and MNO B, the subscribers primarily use MNO A network for services offered by MNO A. However, MNO A can offer simultaneous connection to both MNO A and MNO B for specific services (e.g.: services requiring high data rates) to its premiere subscribers (“golden subscribers”) to get a higher data rate connection by allowing their data traffic to use an extra NR connectivity link from MNO B (with anchor and aggregation in the MNO A CN). Such functionality is assumed to be supported by both MNOs CNs, UEs (of MNO A subscribers), and is associated with a set of traffic policies and conditions, negotiated by the MNOs, which MNO A can control and provision (for its own subscribers).

When outside the coverage footprint of MNO A (but inside the coverage footprint of MNO B), the MNO A subscribers roam on to the MNO B network. As the MNO A subscriber moves in and out of the MNO A coverage, MNO A CN, should be able to switch traffic between the two networks based on the network availability. (Similar to how current ATSSS functionality can switch traffic between the 3GPP and non-3GPP access after losing connectivity to one of the accesses). When the MNO A subscriber enters MNO A coverage, the traffic can be switched from MNO B to MNO A or traffic can be steered on both networks depending on the service type and subscription tier of the MNO A subscriber.

### 5.2.2 Pre-conditions

Alice is a “golden subscriber” of MNO A, while Bob is a “normal subscriber” of MNO A. Alice’s UE is a dual (NR) radio capable.

Based on their subscriber agreement with MNO A, both Alice and Bob can utilize the MNO A network when inside the MNO A coverage and leverage MNO B network when outside the MNO A coverage (supporting traffic switching for mobility scenarios).

In addition, specific traffic policy for Alice, part of MNO A “golden subscriber” agreement includes the use of dual access based on QoS or traffic type, e.g., for high-quality video-calls (supporting traffic steering and splitting).

### 5.2.3 Service Flows

1) Alice and Bob are currently at their home enjoying breakfast on a Saturday morning while surfing the web. They are inside coverage footprint of both MNO A and MNO B. Both are using single access/link to MNO A.

2) They decide to take a stroll to the farmers market less than 2 miles from their home. While travelling towards the market, they decide to stream music online (using MNO A network). Mid way to the market they move outside the coverage footprint of MNO A and the ongoing data traffic is switched from MNO A to MNO B. Now both are outside the coverage footprint of MNO A (but inside the coverage footprint of MNO B) and continue to stream the music without any interruption using MNO B network.

3) While enjoying their Saturday at the Farmer’s market, Alice gets a call from the office for joining an important call from an offshore client in 30min. Alice and Bob start heading back towards their home. Mid way towards their home they move inside the coverage footprint of MNO A and the data traffic is switched from MNO B to MNO A. Now both are inside the coverage footprint of MNO A (and inside the coverage footprint of MNO B) and continue to stream the music without any interruption using MNO A network.

4) After reaching home, Alice decides to start the video call from her device and starts presenting to the offshore client while her son plays video games, and her daughter is streaming movies on Netflix. Alice being the “golden subscriber”, the traffic is now steered or split across both MNO A and MNO B network enabling a high data rate connection for Alice.

5) The client is satisfied with the presentation from Alice. The call ends and Alice goes back to enjoying her Saturday by streaming music using MNO A network.

### 5.2.4 Post-conditions

Alice’s enjoys seamless connectivity while she moves in and out of the coverage of MNO A.

### 5.2.5 Existing features partly or fully covering the use case functionality

None identified.

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

[PR 5.2.6-001] The 5G system shall be able to support mechanisms to enable steering and splitting of UE’s user plane traffic (of the same data session) across two different PLMNs each having a 3GPP access network (e.g. both using NR) and a 5G core network.

[PR 5.2.6-002] The 5G system shall be able to support mechanisms to enable switching of UE’s user plane traffic (of the same data session) for seamless mobility from one PLMN to a different PLMN, each having a 3GPP access network (e.g. both using NR) and a 5G core network.

NOTE: The above requirements assume a single PLMN subscription and a proper business agreement is in place between the two MNOs, including negotiation of specific traffic routing policies and rules.   
Data traffic is assumed to be anchored in the HPLMNs core network.

## 5.3 Use case on Inter-PLMN or PLMN-SNPN scenario

### 5.3.1 Description

This example scenario refers to a stadium, served by ad-hoc/in-venue 5G NR deployment (high-capacity) from one SNPN or PLMN network (MNO-A), plus 5G NR coverage, from the outside the stadium, by another PLMN (MNO-B). There is no NW sharing in place between the two 5G networks.

A picture containing text

Description automatically generated

**Fig. 5.3-1 Stadium scenario**

The above example may similarly apply to other local premises, e.g., campus, enterprise, mall, factory.

MNO-B has business and roaming partnership with MNO-A, including the agreement to lease extra capacity (from MNO-A) to provide ultra-broadband experience to some of MNO-B “golden” customers. The agreement between MNO-A&B entails the ability for those MNO-B users to get higher data rate connection, by allowing their data traffic to use an extra NR connectivity link from PLMN-A’s (with anchor and aggregation in their HPLMN’ CN). Such functionality is assumed to be supported by both PLMNs’ CNs, UEs (of golden MNO-B users), and is associated with a set of traffic policies and conditions, negotiated by the MNOs, which the HPLMN can control and provision (to UEs and CN entities).

### 5.3.2 Pre-conditions

Alice and Bob are at the stadium, for a music concert of their favourite singer. Alice is a golden subscriber of MNO-B, Bob is a “normal” MNO-B customer.

Both their UEs are camped and registered on MNO-B NW, in Idle.

Alice’s UE is dual (NR) radio capable.

The specific traffic policy for Alice, part of MNO-B “golden user” agreement, includes the use of dual access based on QoS or traffic type, e.g., for high-quality video-calls, otherwise MNO-B single access/link should be used.

### 5.3.3 Service Flows

1) Before the concert starts, both Alice and Bob make a voice call to their best friends, describing the atmosphere at the stadium, and promising to share a video of the concert later. Both use single 3GPP access connectivity (via PLMN-B).

*Diagram

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**Fig. 5.3-2 Step-1: Alice & Bob data sessions use single 3GPP access connectivity**

2) After a while, when the concert starts, Alice and Bob decide to start a video call (with their friends), to share their real-time experience (high-quality video settings).   
Alice’s UE registers to NW-A and establishes a dual access connection across the 2 networks.   
Bob’s UE continues to use single access via PLMN-B.

*Diagram

Description automatically generated*

**Fig. 5.3-3 Step-2: scenario with Alice’s data session using dual-3GPP access connectivity**

3) Both Alice and Bob hang up the video-call and continue enjoying the concert.

### 5.3.4 Post-conditions

Alice’s video quality was much better than Bob’s.

### 5.3.5 Existing features partly or fully covering the use case functionality

A) Stage-2&3 include a feature called ATSSS (Access Traffic Steering, Switching, Splitting), e.g., ref to TS 25.301 sec. 5.3.2, which supports functionalities similar to those described in this use case, but limited to 3GPP access plus *non-3GPP* dual access.

B) Existing service requirements, e.g., from TS 22.261 sec. 6.18 and 6.41, capture some general multi-NW connectivity requirements, which do not fully cover or satisfy the specific target use case and functionalities. See some extracts (not exhaustive) listed below:

[Sec. 6.18: Multi-network connectivity and service delivery across operators]

The 5G system shall enable users to obtain services from more than one network simultaneously on an on-demand basis.

For a user with a single operator subscription, the use of multiple serving networks operated by different operators shall be under the control of the home operator.

When a service is offered by multiple operators, the 5G system shall be able to maintain service continuity with minimum service interruption when the serving network is changed to a different serving network operated by a different operator.

NOTE 1: A business agreement is required between the network operators.

In the event of the same service being offered by multiple operators, unless directed by the home operator's network, the UE shall be prioritized to receive subscribed services from the home operator's network.

NOTE 2: If the service is unavailable (e.g., due to lack of network coverage) from the home operator's network, the UE may be able to receive the service from another operator's network.

NOTE 3: QoS provided by the partner operator's network for the same service will be based on the agreement between the two operators and could be different than that provided by the home operator's network.

[Sec. 6.41: PALS]

Based on localized service agreements, the hosting network shall be able to provide required connectivity and QoS for a UE simultaneously connected to the hosting network for localized services and its home network for home network services.

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

[PR 5.3.6-001] The 5G system shall be able to support mechanisms to enable steering, split and switch of UE’s user plane traffic of one data session across two 5G networks (e.g., both using NR access) belonging to two different PLMN operators (one of which is HPLMN), or between the HPLMN and a SNPN.   
It is assumed that the HPLMN subscription is used to access both networks, data traffic is anchored in the HPLMN and a proper business agreement is in place among the two network operators, including specific traffic routing policies, e.g., based on geographical location, subscription, traffic type.

## 5.4 Use case on Inter-PLMN scenario - TN and NTN

### 5.4.1 Description

This use case describes a ski-mountain environment, where 5G NR (terrestrial) coverage is provided by a certain MNO-A (and other MNOs) in limited populated areas (around hotel/resorts and ski areas), together with 5G NTN coverage by MNO-SAT. MNO-SAT has roaming agreement with MNO-A, including roaming connectivity in remote areas where cellular coverage is not available, plus extra services (on-demand) in joint-coverage areas.

*A close-up of a compass

Description automatically generated with low confidence*

**Fig. 5.4.1 Inter-PLMN scenario, with terrestrial and non-terrestrial coverage**

Company GOLD, owning a transport business in the area, recently switched to MNO-A as their enterprise cellular provider. GOLD employees are provided with dual-mode (TN&NTN) UEs.  
MNO-A offers GOLD employees with a “premium” data connectivity plan, based on a (exclusive) commercial agreement with local MNO-SAT, allowing MNO-A premium users to utilize the NTN network to provide extra capacity in areas with dual coverage, for example during high-season months (known to bring load/congestion peaks on NW-A).

In particular, GOLD users can get higher data rate by aggregating their traffic over both cellular (NR) link and an extra NTN connectivity link via PLMN-SAT (with data anchor and aggregation in PLMN-A’ CN). Such functionality assumes support by the UEs (of GOLD users) and both PLMNs’ CNs. It also comes with a set of traffic policies and conditions, negotiated by the MNOs and under HPLMN control (who can provision specific UE and NW traffic rules).

### 5.4.2 Pre-conditions

Alice is a GOLD employee (MNO-A premium subscriber), spending her days doing delivery/transportation services around the area. She uses her smartphone for VPN connectivity (emails, docs/files transfer, video-calls), plus some sporadic web-browsing (e.g., during breaks, for checking news, watching some YouTube videos, etc.).

Based on MNO-A & SAT agreements, traffic policies are such that Alice’s UE can use “premium” (dual-RAT) connectivity for VPN traffic (only).

Alice’s UE is dual (NR) radio capable, currently camped and registered on PLMN-A, in Idle.

### 5.4.3 Service Flows

Alice is in her car, parked outdoor, right after lunch break.

1. She opens the VPN app on the UE to start some large file data transfer from/to her VPN server (to update the morning delivery tasks and download the ones for the afternoon).   
The UE registers to PLMN-SAT and starts a dual 3GPP network connection. VPN data flows over PLMN-A and PLMN-SAT networks, with anchor in PLMN-A’s CN.

*Diagram

Description automatically generated*

**Fig. 5.4-2 Alice’s VPN data session: dual 3GPP access connectivity, across NR and NR-NTN**

2. While waiting for the file transfer, she opens the (non-VPN) web-app to read some news. Non-VPN data traffic uses a normal connection/data session (via PLMN-A).

*Diagram

Description automatically generated*

**Fig. 5.4-3 Dual 3GPP access (VPN traffic) plus concurrent single-access data session (non-VPN)**

3. When done with the file transfer, Alice closes the VPN app, and resumes her work (to complete the afternoon deliveries).

### 5.4.4 Post-conditions

Alice is happy about the very good performance of her mobile VPN connectivity, much faster than other local cellular MNO providers previously used by her company (not partnering with MNO-SAT for the premium connectivity service).

### 5.4.5 Existing features partly or fully covering the use case functionality

A) Stage-2&3 include a feature called ATSSS (Access Traffic Steering, Switching, Splitting), e.g., ref to TS 25.301 sec. 5.3.2, which supports functionalities similar to those described in this use case, but limited to 3GPP access plus *non-3GPP* dual access.

B) Existing service requirements, e.g., from TS 22.261 sec. 6.5 and 6.18, capture some general multi-NW/RAT connectivity requirements, which do not fully cover or satisfy the specific target use case and functionalities. See some extracts (not exhaustive) listed below:

[From sec. 6.5: Efficient user plane]

A 5G system with satellite access shall be capable of supporting simultaneous use of 5G satellite access network and 5G terrestrial access networks.

[From sec. 6.18: Multi-network connectivity and service delivery across operators]

The 5G system shall enable users to obtain services from more than one network simultaneously on an on-demand basis.

For a user with a single operator subscription, the use of multiple serving networks operated by different operators shall be under the control of the home operator.

When a service is offered by multiple operators, the 5G system shall be able to maintain service continuity with minimum service interruption when the serving network is changed to a different serving network operated by a different operator.

NOTE 1: A business agreement is required between the network operators.

In the event of the same service being offered by multiple operators, unless directed by the home operator's network, the UE shall be prioritized to receive subscribed services from the home operator's network.

NOTE 2: If the service is unavailable (e.g., due to lack of network coverage) from the home operator's network, the UE may be able to receive the service from another operator's network.

NOTE 3: QoS provided by the partner operator's network for the same service will be based on the agreement between the two operators and could be different than that provided by the home operator's network.

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

[PR 5.4.6-001] The 5G system shall be able to support mechanisms to enable steering, split and switch of UE’s user plane traffic of one data session across two 5G networks (e.g., between NR terrestrial and satellite RATs) belonging to two different PLMN operators (one of which is the HPLMN). The following is assumed:

* HPLMN subscription is used to access both NWs, data is anchored in the HPLMN and a proper business agreement among the two PLMN operators is in place, including negotiation of traffic routing policies, e.g. based on application type;
* when multiple UE data sessions are established simultaneously (e.g. for different applications), the required mechanisms shall include the ability to use dual network connectivity for one data session, while other data sessions use single NW connection.

## 5.5 Use case on NTN-based dual 3GPP access

### 5.5.1 Description

Aggregating two 3GPP access links simultaneously, of which one is non-terrestrial network, can provide the following 5G service enablers, relevant especially in underserved areas, characterized by limited bandwidth or un-reliable access link:

* Extended Mobile Broadband
* Ultra Reliable service communications

As indicated in TR 38.821, a number of service scenarios (e.g. user in residential homes in remote areas, users on board vehicles, high speed trains, vessels or airplanes), would benefit from the combination of terrestrial and non-terrestrial access or two different non-terrestrial access (e.g. GSO and NGSO based) to meet the targeted service performances in terms of data rate and/or reliability.

The operator of the multi orbit network will also benefit from the flexibility brought by such combination techniques in the optimisation of the network resource usage. The ability to offload delay tolerant traffic components to a GSO access increases the NGSO access network’s capacity for delay sensitive traffic. Moreover, the operator can reduce the service delivery cost where GSO and NGSO access networks have different cost per bit transported.

In underserved areas, the bandwidth provided by a terrestrial based access (e.g. NR or LTE) may be limited at cell edge. Adding a NTN based NG-RAN will be an enable to achieve the targeted experience data rate.

Under some scenarios such as on board high speed trains, the service area may not be fully homogeneous along the rail track and multi connectivity involving NTN-based NG-RAN would enable to provide the targeted reliability.

Hence a UE may be connected and served simultaneously by:

* One NTN-based 3GPP access and one terrestrial-based 3GPP access
* One NTN-based 3GPP access (NGSO) and another NTN-based 3GPP access (GSO)
* One NTN-based 3GPP access (NGSO) via two different satellites of the same constellation

The dual access combining can occur for either the uplink or the downlink or both.

The same or different gNB could serve NR cells via the terrestrial access network and via the satellite access network (e.g. with transparent payload on board the satellite).

NTN based NG-RAN may refer to transparent payload satellites as well as regenerative payload satellites with, for example, some gNB functions on board.

In the following are illustrated:

a) Multi connectivity involving transparent payload NTN-based NG-RAN and terrestrial NG-RAN

A User Equipment is connected to a 5GCN via simultaneously a transparent NTN-based NG-RAN and a cellular NG-RAN. We assume that the NTN Gateway is located in the PLMN area of the cellular access network.

The two following cases are to be considered:

Both PLMNs are managed by different operators (It is assumed that they have a business agreement among them);



Figure 5.5.1a: Multi connectivity involving transparent NTN-based NG-RAN and cellular NG-RAN different PLMN)

Both PLMNs are managed by the same operator.



Figure 5.5.1b: Multi connectivity involving transparent NTN-based NG-RAN and cellular NG-RAN (same PLMN)

b) Multi connectivity involving two transparent NTN-based NG-RAN access

This refers for example to the combination of two Transparent NTN-based NG-RANs e.g. GSO and NGSO based. This can be of interest to provide service to UEs in unserved areas. The NGSO based NG-RAN featuring relatively low latency can be used to support the delay sensitive traffic while the GSO based NG-RAN would provide additional bandwidth to meet the targeted throughput requirements. This is depicted in the figure below.



Figure 5.5.2: Multi connectivity between two transparent NTN-based NG-RAN

c) The combination of two regenerative NTN-based NG-RAN (gNB on board) via two satellites of same constellation with Inter Satellite Links in between. This is depicted in the figure below.



Figure 5.5.3: Multi connectivity between two regenerative NTN-based NG-RAN (e.g. gNB on board)

Notes:

* The figure 5.5.3 is for illustrative purposes. Other architecture (e.g. split NG-RAN architecture between satellite and ground) may be considered;
* SRI refers to satellite radio interface in the figure 5.5.3.
* A UE may be allocated one subscriber identity per access link.
* A UE may implement one or two different modems/radios to access simultaneously both access links.
* The user traffic pertaining to a given service session (e.g. an IP session) may be distributed over two different data paths associated to specific QoS requirements and mapped onto distinct access links.
* The access links may operate in same or different frequency bands.
* The distribution of the user traffic onto the access links is expected to be network controlled

### 5.5.2 Pre-conditions

There shall be some coverage overlap between both NG-RAN access link involved.

In case of same PLMN for both access links, the UE is attached to the 5GC serving both access links.

The 5GC is aware of the respective characteristics of both access links.

In case of different PLMN for the respective access links, UE is subscribed to HPLMN and get access also to the other network through roaming agreement. Information about the respective characteristics of the access links may be exchanged between both networks.

The UE is in connected mode on at least one of the access links.

A slice can be deployed and managed over both access links.

### 5.5.3 Service Flows

The UE establish a VoIP, a video or a data service over one 3GPP access link which appears insufficient in QoS (e.g. throughput, latency, etc.). Given that another 3GPP access link is available, it is activated and combined with the first one to support the required QoS of the service.

According to the targeted QoS of the service, the user plane traffic of the connectivity can be smartly steered, split and switched in both directions between both 3GPP NG-RAN access links taking into account the specific performances of each access link, for example, in terms of latency, throughput, Jitter, Error rate.

The QoS requirements of the user plane traffic can be determined through specific policies associated to different data flows, or different traffic type within the same data flow.

Based on the QoS requirements (e.g. latency, throughput, Jitter, Error rate), traffic characteristics, radio links conditions and UE's moving speed, the traffic is steered/split across the access links. For example low latency requirement traffic will be best split/steered to the access link featuring the lowest latency characteristics.

In case of hand-over, temporary radio link failure or congestion on one access link, the user plane traffic can be switched to the remaining active access link. When the radio link is re-established, the user plane is again split/steered across both access links based on QoS.

The reported data volumes and other traffic statistics, on each access link, are used for billing purposes.

### 5.5.4 Post-conditions

Thanks to appropriate steering, splitting and switching of the user plane traffic, the dual NG-RAN access connectivity involving at least NTN can support the targeted QoS that a single access cannot support. The operator of the multi-orbit network can leverage its GSO access network to increase the capacity of its NGSO access network for delay sensitive and/or optimise the service cost. A network-native standard approach ensures operators can manage the feature in a consistent manner across all users and applications, balancing the needs of individuals with those of the network as a whole.

### 5.5.5 Existing features partly or fully covering the use case functionality

The use case can leverage and extend some of the existing service requirements, e.g. related to

* Multiple access technologies (see §6.3 of TS 22.261)
* Multi-network connectivity and service delivery across operators (see §6.18 of TS 22.261)
* NW Slices (see §6.1 of TS 22.261)
* Efficient user plane (see §6.5 of TS 22.261)

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

[PR 5.5.6-001] Based on operator policy, the 5G system shall be able to support UE's simultaneous data transmission pertaining to the same data session across two 3GPP 5G access networks (using at least one NR satellite RAT), and optimally distribute user traffic between the two access networks, taking into account connectivity conditions on both access networks (e.g. radio characteristics, mobility, congestion) and UE's moving speed.

[PR 5.5.6-002] When two 5G access networks are used simultaneously for the same data session, the 5G system shall be able to collect charging information, for both links simultaneously.

NOTE: In case the two 5G access networks belong to different PLMNs, single subscription and data anchoring in the HPLMN 5G CN are assumed.

## 5.6 Use case on UE using Terrestrial and Satellite Access

### 5.6.1 Description

Satellite access known as wide coverage can improve service availability in areas with poor terrestrial access network coverage or radio condition (e.g. multipath interference). For a UE in high-speed move requests real-time services, e.g. IMS voice/video meeting, it can benefit from dual connectivity with 5G system through terrestrial access and satellite access simultaneously, and obtain the continuous and reliable service with the minimum impact of terrestrial access network unavailability.

Eric is traveling to Saudi Arabia for a business trip. He will take Haramain High-speed Train, which crosses the desert for 450 km distance at a speed of 300 km/h from Makkah to Madinah [2], to visit the customer. During the journey, he has to handle urgent work via online video meetings and solve all the issues before arrival.

A train on the railway tracks

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**Figure 5.6.1-1 Haramain High-speed Train [2].**

### 5.6.2 Pre-conditions

The terrestrial access network of Operator TerrA has good coverage in urban areas, suburban areas, and stopovers along the railway but limited coverage in rural areas and deserts between the stopovers. The satellite access network (e.g. LEO) of Operator SatA has covered the whole country and SatA can provide the communication service on its own.

With the agreement between TerrA and SatA, TerrA can steer or switch the traffic of the same data session of its user over the data paths of the two networks and aggregated in TerrA’s core network.

Eric’s UE e.g. cell phone, or wireless network card is capable of dual 3GPP radio access including satellite access, and has the subscription of TerrA (PLMN NetA) with the service authorization.

By default, only the terrestrial access capability is activated.

### 5.6.3 Service Flows

Eric arrives at Makkah train station and enables the satellite access capability of UE when waiting for the check-in

The UE registers to NetA through terrestrial access and satellite access network with service preference e.g. instant chat with terrestrial access preferred, HD TV with satellite access preferred.

After Eric is on board, the online video meeting starts via the terrestrial access network first. During 1 hour meeting, UE’s traffic will be autonomously steered, or switched between the traffic paths of terrestrial network and satellite network with the assistance of TerrA’s core network, and aggregated in TerrA’s core network to ensure the video meeting is ongoing without obvious service interruption.

When the train reaches the destination, UE will update registration to NetA once Eric disables the satellite access capability.

### 5.6.4 Post-conditions

The video meeting is finished smoothly without interruption.

The user has no awareness of traffic path steering or switching during the video meeting.

### 5.6.5 Existing features partly or fully covering use case functionality

Regarding TS 22.261, 5G system has supported UEs for multiple radio access as below.

*The 5G system shall support UEs with multiple radio and single radio capabilities.*

*Based on operator policy, the 5G system shall support steering a UE to select certain 3GPP access network(s).*

However, when considering user traffic distribution via multiple access networks, satellite access is not in the scope.

*Based on operator policy, the 5G system shall be able to provide simultaneous data transmission via different access technologies (e.g. NR, E-UTRA, non-3GPP), to access one or more 3GPP services.*

*When a UE is using two or more access technologies simultaneously, the 5G system shall be able to optimally distribute user traffic over select between access technologies in use, taking into account e.g. service, traffic characteristics, radio characteristics, and UE's moving speed.*

*The 5G system shall be able to support data transmissions optimized for different access technologies (e.g. 3GPP, non-3GPP) for UEs that are simultaneously connected to the network via different accesses.*

The service continuity is requested in TS22.261 but mainly fulfilled based on Xn-based or N2-based NG-RAN handover as TS 23.502.

*The 5G system shall support service continuity between 5G terrestrial access network and 5G satellite access networks owned by the same operator or owned by different operators having an agreement.*

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

[PR 5.6.6-001] Based on operator policy and agreement, the 5G system shall support a mechanism to steer UE’s data flow(s) of the same data session (i.e. the same service) across, or switch user traffic of the same data session between different 3GPP access networks (i.e. 5G terrestrial and satellite access networks) for UE with dual 3GPP access capability, considering service preference, traffic characteristics, radio characteristics, QoS etc.

[PR 5.6.6-002] Based on operator policy and agreement, the 5G system shall support service continuity with minimum service interruption when steering UE’s data flow(s) of the same data session (i.e. the same service) across, or when switching the user traffic of the same data session between two different 3GPP access networks (i.e. 5G terrestrial and 5G satellite access networks) for UE with dual 3GPP access capability in use, based on network availability, service preference, etc.

## 5.7 Use case on intra-PLMN scenario for XR gaming

### 5.7.1 Description

This use case covers a scenario of one PLMN network with multi- RAT (NR and LTE ) coverages in some hotspot areas.

A picture containing text

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**Fig. 5.7-1 Stadium scenario**

In certain location areas, such as stadium or other event venue, the PLMN MNO-A offers the ability to use dual-RAT connection (LTE and NR) to provide a better service experiences for their customers who have subscribed for the higher grade services (e.g., those Golden users whose UEs also have dual RAT connection capability), for example by offloading some localized service traffic with high data throughput, low latency and high reliability requirements to LTE when the NR network is congested.

### 5.7.2 Pre-conditions

Tom and Jacob are at the stadium, for a football game. Tom is a golden subscriber of MNO-A, Jacob is a “normal” MNO-A customer.

Both their UEs are camped and registered on MNO-A NW, in Idle.

Tom’s UE is dual radio capable (LTE and NR). Tom also brings his AR glasses to allow him to participate to an immersive service provided by MNO-A. This service allows AR glasses to send real time video stream to the server which is hosted in MNO-A inside the stadium, then the server analyses video, renders other information and sent information back to the AR glass, so the user can have fully immersive experience. This AR glass is connected with Tom’s UE using Bluetooth.

The specific traffic policy for Tom, part of MNO-A “golden user” agreement, includes the use of dual access (connecting to both LTE and NR) for certain XR service traffic, e.g., for high-throughput, low latency, high reliability immersive service., otherwise MNO-A single access/link should be used. The specific traffic policy also includes the indication of when and where the dual access connectivity will not be available, e.g., including time and/or location restrictions. For this immersive game service, per MNO-A policy, Tom’s UE cannot connect to both LTE and RAN for dual access after the game is finished.

### 5.7.3 Service Flows

1) Before the game starts, both Tom and Jacob make a voice call to their best friends, describing the atmosphere at the stadium. Both use single NR access connectivity via MNO-A.

2) After a while, when the game starts, Tom wears his AR and starts its immersive service. Tom’s UE registers to both LTE and NR and establishes a dual access connection across the 2 networks. Per the policy defined by MNO-A, Tom’s immersive service traffic (most delay sensitive traffic) is going through NR. Jacob’s UE continues to use single NR access via MNO-A to stream video to his friend.

3) During the game, because many MNO-A users are also sharing the video and pictures using NR RAN, the NR RAN is getting congested. In order to have good user experience, after detecting connection performance is deteriorating in NR network but LTE network is relatively less congested, Tom’s UE and MNO-A CN switch immersive traffic to LTE RAN to avoid service disruption. After NR connection performance is getting better, Tom’s UE and MNO-A switch immersive traffic back to NR network.

4) One hour after the game is finished, the immersive game service is terminated, Tom’s UE is not able to use dual connections to both LTE RAN and NG RAN, and it can only use single RAT access with MNO-A for its communication,

### 5.7.4 Post-conditions

Tom is enjoying the game with that immersive service without service interruption or degradation.

### 5.7.5 Existing features partly or fully covering the use case functionality

A) Stage-2&3 include a feature called ATSSS (Access Traffic Steering, Switching, Splitting), e.g., ref to TS 25.301 sec. 5.3.2, which supports functionalities similar to those described in this use case, but limited to 3GPP access plus *non-3GPP* dual access.

B) Existing service requirements, e.g., from TS 22.261 sec. 6.3, capture some general multi-RAT connectivity requirements, which do not fully cover or satisfy the specific target use case and functionalities. See some extracts (not exhaustive) listed below:

*Based on operator policy, the 5G system shall be able to provide simultaneous data transmission via different access technologies (e.g., NR, E-UTRA, non-3GPP), to access one or more 3GPP services.*

*When a UE is using two or more access technologies simultaneously, the 5G system shall be able to optimally distribute user traffic between access technologies in use, taking into account e.g., service, traffic characteristics, radio characteristics, and UE's moving speed.*

*The 5G system shall be able to support data transmissions optimized for different access technologies (e.g., 3GPP, non-3GPP) for UEs that are simultaneously connected to the network via different accesses.*

*The 5G system shall support UEs with multiple radio and single radio capabilities.*

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

[PR 5.7.6-001] Based on operator policy and dependent on coverage, the 5G system shall be able to support mechanisms to enable switching of UE’s user data of one application between two 3GPP access networks (e.g., using NR and E-UTRA RATs) of the same PLMN operator, in order to meet the QoS requirement of the data application.

NOTE 1: Data routing can be based on traffic policies under network operator control, e.g., depending on QoS requirements, or other conditions or restrictions, such as location, time, connectivity conditions of the access network.

NOTE 2: Considering minimized interruption of service from user perspective.

## 5.8 Use Case on intra-PLMN traffic redundancy

### 5.8.1 Description

This use case covers a scenario of one PLMN network with multi-RAT coverage, NR and LTE, in major cities of the country.

*Diagram

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**Fig. 5.8.1 Intra-PLMN scenario: UE in coverage of two RAN/RATs (NR and LTE)**

In certain hot-spot areas, the PLMN core network offers the ability to use the LTE-based RAN to increase reliability performance (on top of NR) by duplicating UE’s traffic across both RANs, e.g., when the NR-based RAN experiences high-load conditions leading to an increase of packet losses.

### 5.8.2 Pre-conditions

John is a subscriber of MNO-A, and he is located in a hot-spot area (city centre) covered by both NR and LTE RANs, connected to a combined 5GC and EPC.

The LTE NW is quite unloaded, while NR congestion level is more variable (around peak hour).

UE supports dual-3GPP access and dual-radio (including simultaneous traffic) over the two RATs.

UE is registered to PLMN-A, and camped on NR, with no traffic ongoing (idle/inactive).

### 5.8.3 Service Flows

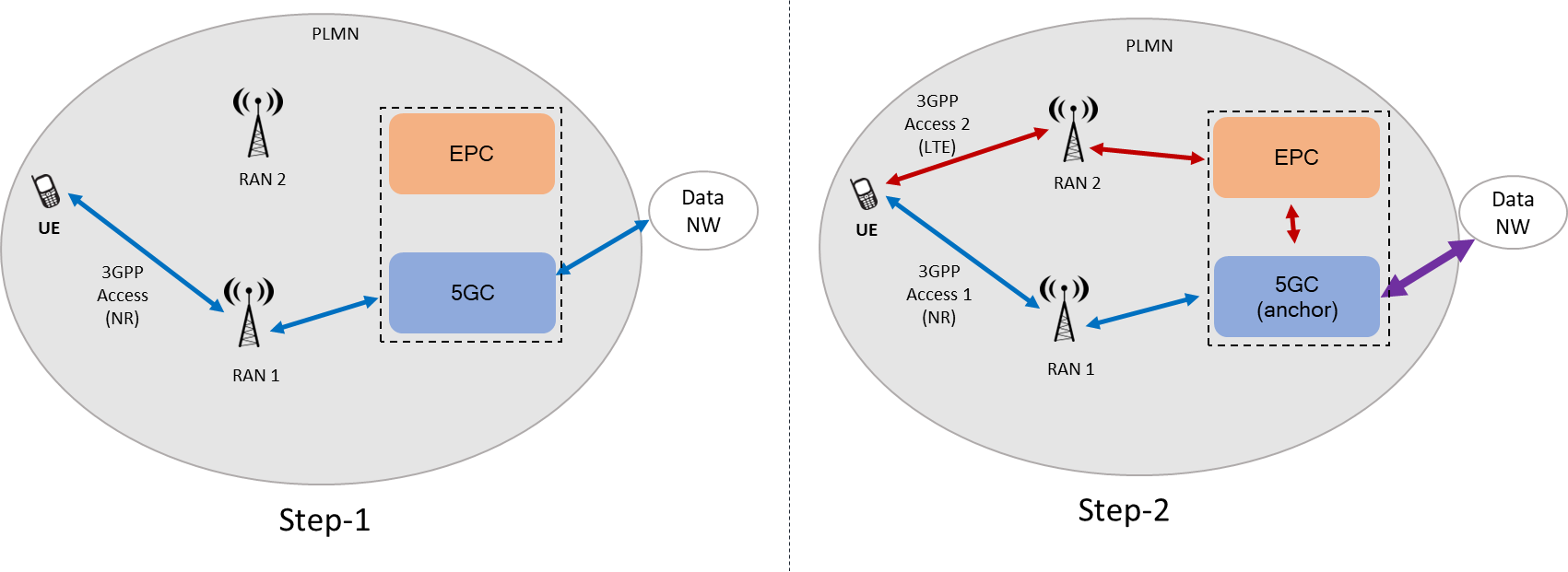
The following steps describe a possible sequence of events, which are assumed to be depending on a set of traffic policies provided to John’s UE and CN (e.g., during registration and/or data session establishment):

1) John starts an e-banking application. Based on the configured traffic policies, such data traffic should use NR access connectivity (when available) as long as reliability conditions (e.g., packet losses) are good enough. Thus, traffic starts flowing over the NR access link.

2) Soon after, reliability performance starts to go down on the NR RAT (e.g., due to higher load), below an acceptable threshold. Based on UE and CN traffic policy conditions/criteria, the same user data is sent (duplicated packets) across both NR and LTE RATs simultaneously, which significantly decreases the packet loss ratio.

3) When the reliability performance on the NR RAT gets better (e.g., lower load), the traffic policy turns off the duplicated packet path over LTE RAT. The session establishment returns to step1.

Figure 5.8.2 shows, at high-level, how UE data traffic is routed and duplicated, during the above steps.

******Fig. 5.8.2** **User data routing: single and dual 3GPP access connectivity.**

### 5.8.4 Post-conditions

John enjoys the e-banking experience on his UE, without any significant QoE impact.

Note: the sequence of steps above is just for illustration purposes; other examples are possible, e.g., connectivity could start and remain over a dual 3GPP access, depending on traffic policies and rules/conditions.

### 5.8.5 Existing features partly or fully covering the use case functionality

A) Stage-2&3 include a feature called ATSSS (Access Traffic Steering, Switching, Splitting), e.g., ref to TS 25.301 sec. 5.3.2, which supports functionalities similar to those described in this use case, but limited to 3GPP access plus *non-3GPP* dual access.

B) Existing service requirements, e.g., from TS 22.261 sec. 6.3, capture some general multi-RAT connectivity requirements, which do not fully cover or satisfy the specific target use case and functionalities. See some extracts (not exhaustive) listed below:

*---------------------------*

*Based on operator policy, the 5G system shall be able to provide simultaneous data transmission via different access technologies (e.g., NR, E-UTRA, non-3GPP), to access one or more 3GPP services.*

*When a UE is using two or more access technologies simultaneously, the 5G system shall be able to optimally distribute user traffic between access technologies in use, taking into account e.g., service, traffic characteristics, radio characteristics, and UE's moving speed.*

*The 5G system shall be able to support data transmissions optimized for different access technologies (e.g., 3GPP, non-3GPP) for UEs that are simultaneously connected to the network via different accesses.*

*The 5G system shall support UEs with multiple radio and single radio capabilities.*

*---------------------------*

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

[PR 5.8.6-001] Based on operator’s policy, the 5G system shall be able to support mechanisms to enable steering and switching of UE’s user data, pertaining to the same application, across two 3GPP networks (e.g., anchored in a combined NR/5GC and E-UTRA/EPC) of the same PLMN operator, using single subscription and including traffic duplication over the two networks, e.g. for higher reliability.

## 5.9 Use case on dual steering through Satellite and UAV

### 5.9.1 Description

Satellite access network is one of the potential technologies that can provide ubiquitous network services to users in poor terrestrial coverage areas. However, satellite coverage may be sparse to users located in interior parts of archaeological or mining sites/in villages covered by dense forests/in a valley/next to a hill or a large building. Thus, dual steering involving satellite access along with Uncrewed Aerial Vehicles (UAVs) (mounted with gNodeB/relay node) would be feasible to provide better connectivity to these underserved areas.

UAVs can either be mounted with gNodeBs or Integrated Access and Backhaul (IAB)-node connecting to IAB-donor station. For UAVs equipped with IAB-nodes, multi-hop backhauling can also be used to extend connectivity to the IAB-donor. UAVs can be connected to the 5G Core (5GC) network through wireless terrestrial backhaul or via satellite connectivity. Consequently, a user may be concurrently linked and served by [Reference: TR 38.821]:

- A Non-Geostationary Earth Orbiting (NGEO) based 5G satellite access network and UAV mounted with gNodeB/ IAB-node.

- A Geostationary Earth Orbiting (GEO) based 5G satellite access network and UAV mounted with gNodeB/IAB-node.

Satellite access points may implement either a transparent or a regenerative payload [Reference: TR 38.821]. A user is connected to the 5GC by satellite access and UAV provided by the same operator simultaneously. Following cases can be considered for the operation of UAV:

- gNodeB functionality is available on board the UAV as shown in Figure 5.9.1.

- UAV can also act as an IAB-node and is further connected with the 5GC as illustrated in Figure 5.9.2.

Diagram

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**Figure 5.9.1. Dual steer involving two 3GPP networks, each using satellite access or UAV (with gNodeB on board)**

Note: the traffic steering and splitting takes place in HPLMN 5GC. Satellite Access Point could either be equipped with transparent or regenerative payload.

Diagram

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**Figure 5.9.2. Dual steer involving two 3GPP networks, each using satellite access or UAV (with IAB-node on board)**

Note: the traffic steering and splitting takes place in HPLMN 5GC. Satellite Access Point could either be equipped with transparent or regenerative payload.

### 5.9.2 Pre-conditions

* There is satellite connectivity in the area but due to non-line of sight conditions, the connection may not be available to a subset of users located in the above mentioned scenarios.
* UAVs should be equipped with gNodeB functionality or IAB-node functionality.
* There is coverage overlap between both the satellite access network and UAV (mounted with gNodeB/relay node).
* UAVs functioning as gNodeB or IAB-node should be able to connect to 5GC through satellite or terrestrial backhaul connectivity.
* The 5GC supports dual steering functionality through UAVs and satellite access.
* The UAVs should be authorized and controlled by the 5G system and Uncrewed Aerial System (UAS) Service Supplier.

### 5.9.3 Service Flows

Alice is presently located around an archaeological site. Initially, she gets dual access, i.e. from 5G satellite access network and through UAV (mounted with gNodeB or IAB node), while 5GC is splitting traffic between the two 3GPP networks. Depending on the targeted Quality of Service (QoS), user plane traffic can be smartly steered, split and switched between these two 3GPP networks in both uplink and downlink directions. The QoS attributes considered for splitting are throughput, error rate, latency and jitter. Traffic steering and splitting may also depend on radio link characteristics along with the user’s velocity. For example, traffic with low latency requirements should be split, steered towards the access link with lowest latency characteristics.

After a while, Alice goes inside the site and starts a video call with her colleagues to get them familiar with the conditions of the site. She may lose connectivity in between with the satellite network for a little while she is inside the site, then all the traffic is handled through the UAV. When she goes outside, satellite based connectivity is restored, 5GC continues to split traffic between the two 3GPP networks. Hence, if congestion on one of the available access links increases or in the scenario of a temporary link failure, then user plane traffic is switched to the other active access link. Once both of the links are active, then depending on the QoS requirements, user plane traffic is again split and steered between the two 3GPP networks.

### 5.9.4 Post-conditions

The intended connectivity is provided without any kind of interruption because of autonomous traffic path steering, switching and splitting provided using both the access links.

### 5.9.5 Existing features partly or fully covering the use case functionality

This use case may leverage and expand current service requirements, such as those linked to:

* Access Traffic Steering, Switching, Splitting (ATSSS) feature as mentioned in the clause 5.3.2 of TS 23.501 supports similar functionalities as listed in this use case, but dual access connectivity is limited to one 3GPP access and one non-3GPP access.
* The 5G system shall support UAS connectivity and its associated procedures related to proper functioning of UAS such as Commands and Control (C2) connectivity, tracking etc. [Reference: TS 23.256]
* The 5G system shall support connectivity using satellite access. [Reference: TS 22.261]
* The 5G system shall support service continuity between two access (satellite and UAV) networks. [Reference: TS 23.501]

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

[PR 5.9.6-001] The 5G system shall be able to support simultaneous data transmission across two 3GPP networks for the same data session, using satellite access and terrestrial access (e.g., via a gNodeB or IAB-node mounted on UAV) while considering QoS requirements between these two 3GPP networks.

[PR 5.9.6-002] The 5G system shall be able to collect charging information for simultaneous data transmission pertaining to the same user data session across two 3GPP networks.

## 5.10 Use case on NTN and TN Inter-PLMN Multi-access in a Maritime scenario

### 5.10.1 Description

This use case describes a maritime scenario where multiple satellite PLMNs and a terrestrial 5G PLMN are simultaneously used.

MNO-G is a well-established satellite PLMN operator and operates several GEO satellites. The MNO-L is a relatively new satellite PLMN operator and operates the LEO satellites constellation. MNO-G and MNO-L have deployed their satellite networks based on the 5G systems. MNO-T has a terrestrial 5G PLMN infrastructure in an island country A, whose territory is surrounded by sea. MNO-T provides 5G access coverage not only to the territory of country A but also to its coast. MNO-G has business and roaming agreements with MNO-L and MNO-T.

Company X owns several large container vessels. Company X's vessels are used for domestic and international goods transportation. Company X operates a vessel operation center. A vessel is equipped with a VSAT-type UE, which is mainly used for communication with the vessel operation center. The vessel operation center has been monitoring the vessel's location information and providing operational information (e.g., route planning). Company X has traditionally used GEO satellite access by MNO-G for communication. Company X wishes to add LEO satellite access by MNO-L and terrestrial 5G access by MNO-T to be used simultaneously with GEO satellite access to improve communication stability and resiliency, reduce latency, and increase capacity. Thanks to the large coverage area of the GEO satellite of MNO-G, the UE can be assumed to be always under the GEO satellite access in the vessel navigation route. The LEO satellite constellation of MNO-L will be deployed globally, but the coverage will be discontinuous. The terrestrial 5G access network covers approximately 20 km from the coast. Therefore, the UE will be basically connected to the GEO satellite, while terrestrial 5G access and LEO satellite access will be connected only when available.

Remote control of the vessels includes short-term and long-term route controls. Since remote control of short-term route planning requires real-time communication and high-traffic data communication, it is only enabled when the vessel is connected to the LEO satellite access or the terrestrial 5G access. Web-browsing data communication for crews will be available when there is sufficient capacity in communication for remote control of the vessel. The traffic data are described in the table below.

**Table. 5.10-1** **Traffic data requirements**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Traffic Data | Use case | Priority | Delay Sensitivity | Traffic Capacity |
| Vessel Control  (Real-time) | Communications for short-term route planning. Real-time communication is required. | High | High | Middle |
| Vessel Control  (Non-Real-time) | Communications for long-term route planning. Real-time communication is not required, but periodic communication is required. | High | Low | Low |
| Vessel Monitoring  (Real-time) | Realtime video transmission around a vessel for short-term route planning | Middle | High | Middle ~High(NOTE) |
| Vessel Monitoring  (Non-Real-time) | Data communication for monitoring of all equipment on board  (e.g., fuel level logs, engine condition logs, etc.) | Middle | Low | Low |
| Emergency Alert | Communication for critical alerts in operating a vessel.  (e.g., vessel collisions, fuel leaks, etc.) | High | High | Low |
| Web-browsing | Data communication for crew members  (e.g., e-mail, YouTube, Netflix, etc.) | Low | Low | Low ~ High |

NOTE: The traffic capacity of Realtime video data can be controlled based on the available capacity. When capacity is not sufficient, the video resolution can be reduced.

### 5.10.2 Pre-conditions

MNO-G has business and roaming agreements with MNO-L and MNO-T.

Company X's vessel is a subscriber of MNO-G, which is its HPLMN. The UE installed on the vessel is capable of multi-access to the GEO satellite, the LEO satellite, and the terrestrial 5G access.

Alice and Bob are company X’s employees. Alice works in the vessel operation center and Bob works on the vessel as a crew.

Alice is spending her days doing remote control and monitoring of the vessel from the vessel operation center. Alice controls the vessel's route plan remotely using communications between the vessel operation center and the VSAT-type UE on the vessel in response to monitoring status and weather conditions around the vessel.

Bob is spending his days controlling and monitoring the vessel when short-term route control from the vessel operation center is not accessible. As a benefit, web browsing, e-mail, and YouTube viewing are available when communication capacity is available.

### 5.10.3 Service Flows

Diagram

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**Fig. 5.10-1 Maritime scenario, with a terrestrial 5G access and multiple satellite access**

The scenario is shown in the Fig 5.10-1, MNO-G and MNO-L are both operators with separate 5G core networks.

0. Alice controls the vessel remotely from the vessel operation center, checking the weather and other data sent from the vessel's onboard multi-access VSAT-type UE. Bob monitors and controls the ship on board and is allowed to browse the web, send and receive e-mails, and view entertainment videos when sufficient communication capacity is available as a benefit.

1. The vessel's route is basically under the GEO satellite coverage, and when the vessel is connected only to the GEO satellite, real-time data communication is not enabled. Alice remotely commands long-term route planning based on Non-Real-time Vessel Control Data and Vessel Monitoring Data. Bob monitors and conducts short-term route changes on the vessel. Emergency Alert data communication will be sent as a top priority even if real-time communication is not available.

2. When the vessel moves into an area where both the GEO and the LEO satellite coverage is present, the VSAT-type UE is also connected to LEO (i.e., simultaneously connected to the GEO satellite and the LEO satellite). In addition to long-term route planning, Alice also remotely commands short-term route changes based on Real-time Vessel Control Data and Vessel Monitoring Data via the LEO satellite. In this case, only Bob monitors the vessel.

3. When the vessel approaches the coast and moves into terrestrial 5G access coverage, the VSAT-type UE is connected to terrestrial 5G access even if it is within the LEO satellite coverage (GEO and terrestrial 5G access). The vessel’s monitoring and remote control are performed in the same way as in step 2.

4. When the vessel moves out of the LEO satellite coverage, the VSAT-type UE’s connection is unchanged. The vessel’s monitoring and remote control are performed in the same way as in step 2.

5. After some time, when there is only the GEO satellite coverage, the vessel’s monitoring and remote control return to the state of Step 1.

### 5.10.4 Post-conditions

Although Company X's vessel experienced bad communication conditions due to the inevitable heavy rainfall along its route, by prioritizing critical communications, Alice and Bob were able to control the vessel efficiently and make the vessel reach its destination safely.

### 5.10.5 Existing features partly or fully covering the use case functionality

The use case can leverage the existing service requirements described below but some extensions are required to fully support the use case.,

[From TS22.261 sec. 6.3: Multiple access technologies]

*Based on operator policy, the 5G system shall be able to dynamically offload part of the traffic (e.g., from 3GPP RAT to non-3GPP access technology), taking into account traffic load and traffic type.*

*When a UE is using two or more access technologies simultaneously, the 5G system shall be able to optimally distribute user traffic over select between access technologies in use, taking into account e.g., service, traffic characteristics, radio characteristics, and UE's moving speed.*

[From TS22.261 sec. 6.5: Efficient user plane]

*For a 5G system with satellite access, the following requirements apply:*

* *A 5G system with satellite access shall be able to select the communication link providing the UE with the connectivity that most closely fulfils the agreed QoS*
* *A 5G system with satellite access shall be capable of supporting simultaneous use of 5G satellite access network and 5G terrestrial access networks.*
* *A 5G system with satellite access shall be able to support both UEs supporting only satellite access and UEs supporting simultaneous connectivity to 5G satellite access network and 5G terrestrial access network.*

[From TS22.261 sec. 6.18: Multi-access connectivity and service delivery across operators]

*When a service is offered by multiple operators, the 5G system shall be able to maintain service continuity with minimum service interruption when the serving network is changed to a different serving network operated by a different operator.*

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

[PR 5.10.6-001] The 5G system shall be able to support mechanisms to enable steering, splitting, and switching of UE’s with single subscription and user data across two different PLMNs (one of which is the HPLMN) e.g., using dual satellite NG-RANs or a satellite and a terrestrial NG-RAN, and traffic anchoring in the HPLMN’s 5G core network.

[PR 5.10.6-002] The 5G system shall be able to support mechanisms, for UEs using dual 3GPP access across a HPLMN and a second PLMN, to enable switching of UE’s user data from the second PLMN (a VPLMN) to a third PLMN (another VPLMN) while maintaining one access link with the HPLMN.

NOTE 1: Certain information (e.g., user’s service preferences such as QoS) can be considered.

NOTE 2: UE can be connected to maximum two PLMNs simultaneously, including one HPLMN.

NOTE 3: One of the dual accesses is in HPLMN and it is always used.

## 5.11 Use case on inter PLMN scenario for XR service

### 5.11.1 Description

This example scenario refers to a stadium, served by ad-hoc/in-venue 5G NR deployment (high-capacity) from one PLMN network (MNO-A), plus 5G NR coverage, from inside and outside the stadium, by another PLMN (MNO-B). There is no NW sharing in place between the two 5G networks.

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**Fig. 5.11-1 Stadium scenario**

The above example may similarly apply to other local premises, e.g., campus, enterprise, mall, factory.

MNO-A has business and roaming partnership with MNO-B, including the agreement to lease extra capacity (from MNO-B) to provide ultra-broadband experience to some of MNO-A “golden” customers. The agreement between MNO-A&B entails the ability for those MNO-A users to get higher data rate connection, by allowing their data traffic to use an extra NR connectivity link from PLMN-B’s (with anchor and aggregation in their HPLMN’ CN). Such functionality is assumed to be supported by both PLMNs’ CNs, UEs (of golden MNO-A users), and is associated with a set of traffic policies and conditions, negotiated by the MNOs, which the HPLMN can control and provision (to UEs and CN entities).

### 5.11.2 Pre-conditions

Tom and Jacob are at the stadium, for a football game. Tom is a golden subscriber of MNO-A, Jacob is a “normal” MNO-A customer.

Both their UEs are camped and registered on MNO-A network, in Idle.

Tom’s UE is dual (NR) radio capable. Tom also brings his AR glasses to allow him to participate to an immersive service provided by MNO-A. This service allows AR glasses to send real time video stream to the server which is hosted in MNO-A inside the stadium, then the server analyses video, renders with other information and send information back to the AR glasses, so the user can have fully immersive experience. The AR glasses are connected with Tom’s UE using Bluetooth.

The specific traffic policy for Tom, part of MNO-A “golden user” agreement, includes the use of dual access (connecting to both MNO-A and MNO-B) for certain URLLC service traffic, e.g., for high-throughput, low latency, high reliability immersive service., otherwise MNO-A single access/link should be used. The specific traffic policy also includes the indication of when or where the dual access will not be available, such as time and location restrictions. For this immersive game service, per MNO-A policy and agreement between MNO-A and MNO-B, Tom’s UE cannot connect to MNO-B for dual access after game is finished.

### 5.11.3 Service Flows

1) Before the game starts, both Tom and Jacob make a voice call to their best friends, describing the atmosphere at the stadium. Both use single 3GPP access connectivity via MNO-A network.

2) After a while, when the game starts, Tom wears his AR glasses and starts its immersive service. Tom’s UE registers to both MNO-A and MNO- B and establishes a dual access connection across the two networks. Per the policy defined by MNO-A and the SLA between MNO-A and MNO-B, Tom’s 80% of the immersive service traffic is going through MNO\_A network while the rest is being steered to MNO-B network.   
Jacob’s UE continues to use single access via MNO-A network to stream video his friend.

3) During the game, because many MNO-A users are also sharing the video and pictures, the MNO-A is getting congested. In order to have good user experience for the golden customer, after detecting connection performance is deteriorating, Tom’s UE and MNO-A CN steer more immersive traffic to MNO-B to avoid service disruption based on MNO-A’s policy. After MNO-A network connection performance is getting better, Tom’s UE and MNO-A CN steer more immersive traffic back to MNO-A network.

4) One hour after the game is finished, the immersive game service is terminated. Tom’s UE is not able to register to MNO-B network and it can only use single access with MNO-A network for its communication,

### 5.11.4 Post-conditions

Tom is enjoying the game with that immersive service without service interruption or degradation.

### 5.11.5 Existing features partly or fully covering the use case functionality

A) Stage-2&3 include a feature called ATSSS (Access Traffic Steering, Switching, Splitting), e.g., ref to TS 25.301 sec. 5.3.2, which supports functionalities similar to those described in this use case, but limited to 3GPP access plus *non-3GPP* dual access.

B) Existing service requirements, e.g., from TS 22.261 sec. 6.18 and 6.41, capture some general multi-NW connectivity requirements, which do not fully cover or satisfy the specific target use case and functionalities. See some extracts (not exhaustive) listed below:

[Sec. 6.18: Multi-network connectivity and service delivery across operators]

The 5G system shall enable users to obtain services from more than one network simultaneously on an on-demand basis.

For a user with a single operator subscription, the use of multiple serving networks operated by different operators shall be under the control of the home operator.

When a service is offered by multiple operators, the 5G system shall be able to maintain service continuity with minimum service interruption when the serving network is changed to a different serving network operated by a different operator.

NOTE 1: A business agreement is required between the network operators.

In the event of the same service being offered by multiple operators, unless directed by the home operator's network, the UE shall be prioritized to receive subscribed services from the home operator's network.

NOTE 2: If the service is unavailable (e.g., due to lack of network coverage) from the home operator's network, the UE may be able to receive the service from another operator's network.

NOTE 3: QoS provided by the partner operator's network for the same service will be based on the agreement between the two operators and could be different than that provided by the home operator's network.

[Sec. 6.41: PALS]

Based on localized service agreements, the hosting network shall be able to provide required connectivity and QoS for a UE simultaneously connected to the hosting network for localized services and its home network for home network services.

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

[PR 5.11.6-001] The 5G system shall be able to support mechanisms to enable dynamic steer, split and switch of UE’s user data across two 5G networks concurrently (e.g., both using NR access), belonging to two different PLMN operators (one of which is HPLMN) , in order to meet the QoS requirement of the data session .

NOTE 1: It is assumed that the HPLMN subscription is used to access both networks, data traffic is anchored in the HPLMN and a proper business agreement is in place among the two network operators, including specific traffic routing policies, e.g., based on geographical location, subscription, traffic type.

NOTE 2: Data routing can be based on traffic policies under home network operator control, e.g., depending on business agreeemnt between home network operator and other network operator, QoS requirements and other conditions or restrictions, e.g., based on location, time, connectivity conditions.

## 5.12 Use case on different VPLMN scenarios

### 5.12.1 Description

Some of the previous use cases and potential requirements cover dual 3GPP access operation in one PLMN, or between two PLMNs, or between PLMN and SNPN, assuming one PLMN is the Home PLMN. Similar scenarios can be extended to the case of a UE/User being in coverage of one or two VPLMNs (or a VPLMN and SNPN), e.g., for UEs roaming abroad.

In the scenario of a UE in coverage of one VPLMN, traffic may be anchored and routed via the HPLMN or in the VPLMN itself (e.g., using local breakout). These two options are depicted in Figures 5.12.1 and 5.12.2.

A picture containing text, clock, gauge

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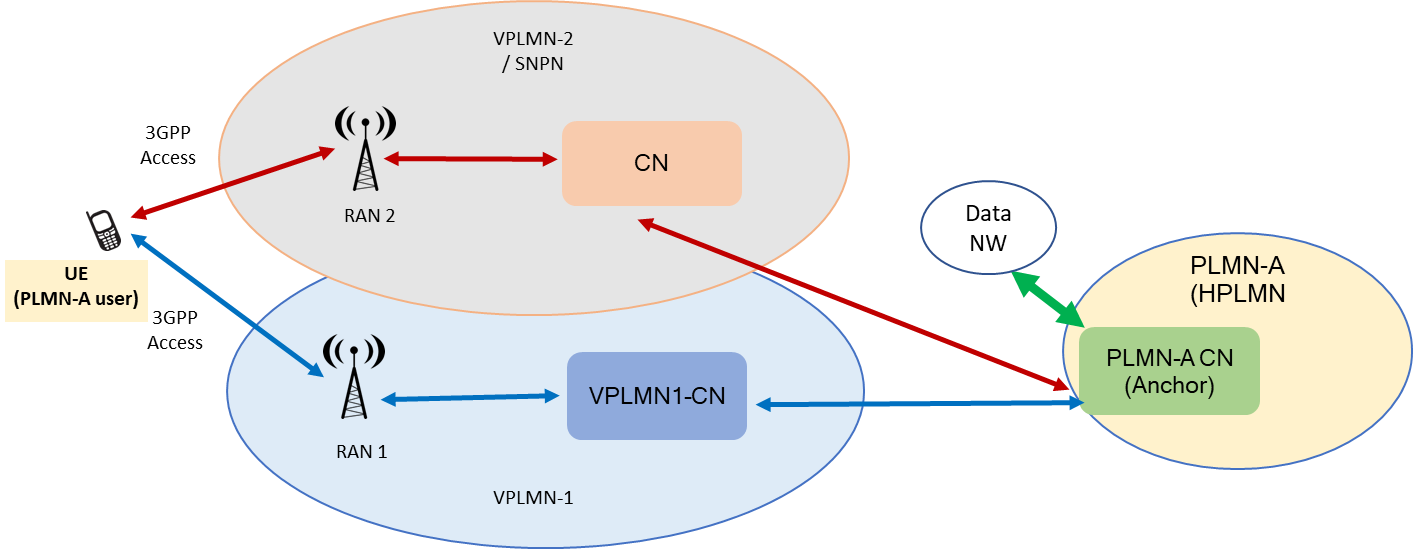
**Fig.5.12.1 Intra-VPLMN scenario, with home-routed traffic**

Diagram

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**Fig. 5.12.2 Intra-VPLMN scenario, with local breakout**

The scenario of inter-VPLMN, or between a VPLMN and a SNPN, is illustrated in Figure 5.12.3 below, assuming home routed traffic.



**Fig. 5.12.3 Inter-VPLMN scenario, with home-routed traffic**

The option of inter-VPLMN using local breakout in one VPLMN is not considered.

As a particular example of the above scenarios, one can consider the following use case: a media company “BETA”, specialized in real-time outdoor events recording and broadcasting (e.g., sport races), uses a set of professional 5G-capable devices/cameras with a premium subscription to their home operator, which provides a high QoS/Tput connectivity including the option to use dual 3GPP access if/when available. BETA may work internationally, i.e., can be tasked to record live events in other countries; for such cases, based on proper business/roaming agreements between BETA’s HPLMN and the local VPLMN(s), the subscription enables their devices and service to obtain premium connectivity also when in VPLMN coverage, including dual 3GPP access (if/when supported by the VPLMN).

### 5.12.2 Pre-conditions

BETA has been asked to capture a live sport race event (e.g., cycling) in a rural/mountain area where there may be both terrestrial and satellite coverage, from the same PLMN or two different PLMNs, both with roaming agreement with the BETA’s HPLMN. It can also be that local terrestrial coverage, along the route, is provided by a SNPN.

BETA’s cameras are equipped with 5G dual radio capable UEs and configured to use both terrestrial and satellite RATs to aggregate real-time video data to be sent/uploaded to their TV broadcast centre connected to the 5G core network. The dual 3GPP access provisioning is based on specific agreements and policies between the HPLMN and the VPLMN(s).

### 5.12.3 Service Flows

1) Cameras/UEs are activated, before the event, and registered on the VPLMN(s), in idle.

2) Prior to the race, high-definition video connectivity is established, using a dual 3GPP access session over both terrestrial and satellite RATs.

3) Video data is uploaded in real-time using data aggregation over the two 3GPP access links.

### 5.12.4 Post-conditions

The sport race is live broadcast on TV, with very high video quality.

### 5.12.5 Existing features partly or fully covering the use case functionality

A) Stage-2 and Stage-3 include a feature called ATSSS (Access Traffic Steering, Switching, Splitting), e.g., ref to TS 25.301 sec. 5.3.2 and 25.302, which supports functionalities similar to those described in this use case, but limited to a 3GPP access plus a *non-3GPP* dual access.

B) Existing service requirements, e.g., from TS 22.261 sec. 6.3, 6.18 and 6.41, capture some general multi-RAT and multi-NW connectivity requirements, which do not fully cover or satisfy the specific target use case and functionalities. See some extracts (not exhaustive) listed below:

*[Sec. 6.3]*Based on operator policy, the 5G system shall be able to provide simultaneous data transmission via different access technologies (e.g., NR, E-UTRA, non-3GPP), to access one or more 3GPP services.

When a UE is using two or more access technologies simultaneously, the 5G system shall be able to optimally distribute user traffic between access technologies in use, taking into account e.g., service, traffic characteristics, radio characteristics, and UE's moving speed.

The 5G system shall be able to support data transmissions optimized for different access technologies (e.g., 3GPP, non-3GPP) for UEs that are simultaneously connected to the network via different accesses.

The 5G system shall support UEs with multiple radio and single radio capabilities.

*[Sec. 6.18: Multi-network connectivity and service delivery across operators]*The 5G system shall enable users to obtain services from more than one network simultaneously on an on-demand basis.

For a user with a single operator subscription, the use of multiple serving networks operated by different operators shall be under the control of the home operator.

When a service is offered by multiple operators, the 5G system shall be able to maintain service continuity with minimum service interruption when the serving network is changed to a different serving network operated by a different operator. NOTE: A business agreement is required between the network operators.

*[Sec. 6.41: PALS]*

Based on localized service agreements, the hosting network shall be able to provide required connectivity and QoS for a UE simultaneously connected to the hosting network for localized services and its home network for home network services.

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

[PR 5.12.6-001] The 5G system shall be able to support mechanisms to enable data aggregation of UE’s user data across two 3GPP networks belonging to the same PLMN, two PLMNs, or a PLMN and a SNPN, where each PLMN is a VPLMN. In case of inter-VPLMN scenarios, user data shall be anchored in the HPLMN’s core network. In case of intra- VPLMN scenarios, user data can also be anchored in the VPLMN, i.e. using VPLMN local breakout.

## 5.13 Use case on Interworking with non-3GPP access

### 5.13.1 Description

Current specifications (up to Rel-18) include support of so called ATSSS (Access Traffic Steering, Switching, Splitting) including multi-NW connectivity across 3GPP and non-3GP accesses.

In certain scenarios it would be beneficial to support transition between new dual-3GPP access operation and ATSSS-based operation, e.g., when coverage of one of the two 3GPP accesses becomes poor or unavailable, while a non-3GPP access link is available. One relevant scenario is when a UE/user moves from outdoor to indoor (and vice versa), can be home, office, enterprise, shopping mall or other type of venues.

For example, let’s assume a certain enterprise (“Business”) with mobile and Wi-Fi subscriptions offered to his employees, from the same MNO (“MNO-A”), which includes the use of dual 3GPP access and/or ATSSS for high data rate connectivity, e.g., for intranet video calls, outside or inside the enterprise office buildings.

### 5.13.2 Pre-conditions

MNO-A cellular coverage around the enterprise area includes LTE and NR; NR repeaters and small cells are also deployed inside Business buildings.

Both devices and MNO’s Core network support dual 3GPP access as well as ATSSS functionalities.

Bob, one employee of Business, uses to move between buildings of his enterprise campus, and often takes video calls on his phone while commuting.

Based on agreements and policies between Business and MNO, video calls data traffic should use dual access connectivity to improve QoE, either over NR and LTE cellular links when outdoor, or over NR and Wi-Fi when UEs are indoor.

### 5.13.3 Service Flows

1) Bob is outdoor, during a video call, connected via dual 3GPP access to both MNO RATs, as shown in the following figure:

A close-up of a speedometer

Description automatically generated with medium confidence

**Fig.5.13.1 Outside the office**

2) When Bob moves inside his office building, the quality of one cellular RAT degrades, while good Wi-Fi coverage becomes available. As such, based on configured traffic policies, the connectivity changes using ATSSS between one cellular RAT and Wi-Fi, as shown in Figure 5.13.2.

Diagram

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**Fig.5.13.2 Inside the office**

3) The connectivity can change back to dual 3GPP access (step 1) if/when Bob exits the building

### 5.13.4 Post-conditions

Bob can experience higher quality video connectivity while moving between outdoor and indoor locations.

### 5.13.5 Existing features partly or fully covering the use case functionality

A) Stage-2&3 include a feature called ATSSS (Access Traffic Steering, Switching, Splitting), e.g., ref to TS 25.301 sec. 5.3.2, limited to 3GPP access plus *non-3GPP* access.

B) Existing service requirements, e.g., from TS 22.261 sec. 6.3, capture some general multi-RAT connectivity requirements, which do not fully cover or satisfy the specific target use case and functionalities. See some extracts (not exhaustive) listed below:

*---------------------------*

*Based on operator policy, the 5G system shall be able to provide simultaneous data transmission via different access technologies (e.g., NR, E-UTRA, non-3GPP), to access one or more 3GPP services.*

*When a UE is using two or more access technologies simultaneously, the 5G system shall be able to optimally distribute user traffic between access technologies in use, taking into account e.g., service, traffic characteristics, radio characteristics, and UE's moving speed.*

*The 5G system shall be able to support data transmissions optimized for different access technologies (e.g., 3GPP, non-3GPP) for UEs that are simultaneously connected to the network via different accesses.*

*The 5G system shall support UEs with multiple radio and single radio capabilities.*

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

[PR 5.13.6-001] The 5G system shall be able to support means to transition from a UE data connection related to single subscription using two 3GPP networks to a connection using 3GPP and non-3GPP access (e.g., ATSSS), and vice versa.

NOTE: The 3GPP and non-3GPP access networks are assumed to be managed by the same MNO, and data is anchored in the same 5G core network of the HPLMN.

## 5.14 Use Case on Inter-PLMN scenario - TN and multiple NTN

### 5.14.1 Description

This use case describes a rural environment, where an MNO (TerrA) provides local terrestrial coverage only near cities, and where an MNO (SatA) provides wide NTN coverage. SatA uses satellites in both a GSO orbit and a NGSO orbit. SatA has a roaming agreement with TerrA, to allow:

* connectivity for **all users of TerrA** when these users are not in terrestrial coverage; and
* user plane steering, switching, splitting, and duplication functionality to the **premium users of TerrA** when these premium users are simultaneously in terrestrial and non-terrestrial coverage.



**Fig. 5.14.1 Inter-PLMN scenario, with terrestrial and multiple non-terrestrial coverage**

Such use case can also apply to a PLMN plus NPN scenario, as well as an intra-PLMN scenario (one or two partner MNOs using the same PLMN-ID across different RATs).

Jenny has just moved to the city and is looking to buy a home for her family. She often needs to wait for her son while he is at his soccer practices. Sometimes to pass the time while waiting, she uses her virtual reality headset to virtually visit homes in the area.

### 5.14.2 Pre-conditions

- Jenny is at her son’s soccer practice. The soccer training pitch is located in an area that has both terrestrial and non-terrestrial coverage.

- Jenny is a subscriber and premium user of TerrA.

- Jenny’s virtual reality headset is dual access link capable (terrestrial and satellite access).

- Jenny’s virtual reality headset is registered on TerrA.

- Based on TerrA & SatA agreements, traffic policies are such that Jenny’s virtual reality headset can use dual- PLMN/RAT connectivity, including two options for connecting to SatA – through satellite access (GSO and/or NGSO).

### 5.14.3 Service Flows

1. Jenny wants to virtually visit some homes. She puts on her virtual reality headset and starts the Virtual Home Visit app. As the app allows her to virtually walk through and interact with the home, low latency is required for a good end user experience.

2. Performance on the terrestrial network degrade. Based on configured traffic policies, in order to better meet the low latency requirement of the Virtual Home Visit app, the headset selects the NGSO satellite RAT of SatA to start a dual 3GPP access connection.

3. The virtual reality headset registers to SatA over the NGSO satellites, and starts a dual 3GPP network connection. Traffic from the app flows over TerrA network and SatA, with anchor in TerrA’s core network.

### 5.14.4 Post-conditions

- The soccer practice ends, and Jenny closes the Virtual Home Visit app.

- Jenny enjoyed her experience and has constructively made use of her time while waiting for her son.

### 5.14.5 Existing features partly or fully covering the use case functionality

**[From 3GPP TS 25.301 [4] clause 5.3.2]**

ATSSS (Access Traffic Steering, Switching, Splitting) allows user plane traffic to be split, steered, switched, duplicated over two access legs - one 3GPP and one non3GPP*.* The feature does not support the case where the two access legs are both over 3GPP.

**[From 3GPP TS 22.261 [3] clause 6.3 Multiple access technologies]**

* The 5G system shall be able to provide services using satellite access.
* The 5G system shall support UEs with multiple radio and single radio capabilities.
* Based on operator policy, the 5G system shall support steering a UE to select certain 3GPP access network(s).

**[From 3GPP TS 22.261 [3] clause 6.5 Efficient user plane]**

* A 5G system with satellite access shall be able to select the communication link providing the UE with the connectivity that most closely fulfils the agreed QoS.
* A 5G system with satellite access shall be capable of supporting simultaneous use of 5G satellite access network and 5G terrestrial access networks.

**[From 3GPP TS 22.261 [3] clause 6.18 Multi-network connectivity and service delivery across operators]**

* The 5G system shall enable users to obtain services from more than one network simultaneously on an on-demand basis.
* For a user with a single operator subscription, the use of multiple serving networks operated by different operators shall be under the control of the home operator.
* When a service is offered by multiple operators, the 5G system shall be able to maintain service continuity with minimum service interruption when the serving network is changed to a different serving network operated by a different operator.
* In the event of the same service being offered by multiple operators, unless directed by the home operator's network, the UE shall be prioritized to receive subscribed services from the home operator's network.

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

[PR 5.14.6-001] The 5G system shall be able to support mechanisms to allow a home PLMN to provide a UE with policies for the UE to connect to an additional PLMN with potentially a different RAT or to an additional RAT within the same PLMN for splitting, steering or switching of traffic pertaining to the same data session that is sent across these two access networks.

NOTE 1: The policies and criteria can consider e.g. geographical location, connectivity conditions on both access networks, UE capabilities and QoS.

NOTE 2: The above requirement also applies to intra-PLMN or inter-PLMN scenarios where the 2nd PLMN is an NPN.

NOTE 3: Single subscription and the business agreement between two network operators are assumed.

## 5.15 Use Case on access to local NPN services (inter NPN – PLMN scenario)

### 5.15.1 Description

Autonomous guided vehicles (AGVs) are expected to be an essential part of smart manufacturing, logistics and warehousing. They will be able to perform various industrial tasks, including material handling, collaborative work with humans or cooperative activities with other AGVs/Automated Mobile Robots (AMRs). This next generation of AGVs will have a remote control system that will guide such AGVs, whereby the control system host will reside in a private data network. Such AGVs with a remote controller form a closed-loop system, requiring timely delivery of commands, feedback and, generally, access to services. AGVs may also access other (micro)services in the edge cloud. The communication link(s) between the control system and AGV must be reliable in both directions. They also need to provide the required QoS in up-link and downlink to ensure AGVs’ safe and efficient operation and enable flexibility of the routes that they may take.

In a smart manufacturing plant or a warehouse, such an AGV may be e.g. moving material from the outdoor loading areas to the inside of the plant and vice versa. The outside loading area may not be in the immediate vicinity of the plant and, hence, not within the coverage of a Public network integrated NPN (PNI-NPN) operator. Furthermore, such AGVs may be required to transport the material between multiple sites in a locality where there is limited or no NPN coverage between the sites. Also, the distance between different sites may be too large for an NPN to cover.

This use case addresses the requirement for such AGV’s smooth mobility and access to (micro)services residing in the NPN’s private network via MNO’s access network when AGV is moving in- and out of the coverage footprint of NPN. For example, as it moves through the plant and outside the plant, the AGV may be required to provide real-time video feed to the control system, based on which AGV is navigated. Furthermore, it should be possible that, based on the AGV’s QoS requirements and the conditions of two networks (e.g. availability and available capacity), both networks are utilised so that private data traffic to and from AGV can be split or steered.

NOTE: As stated in TS 22.104, AGVs are a sub-group of mobile robots. In this use case, the term AGV refers to the future generation of AGVs, which can be controlled remotely, e.g. from the edge cloud, enabling flexible route navigation.

Diagram

Description automatically generated

**Figure 5.15.1. In a vicinity of the plant, NPN-OP#1 & MNO-A provide 3GPP access networks for provision of highly reliable and high-quality connectivity to the NPN’s edge-cloud based services.**

### 5.15.2 Pre-conditions

AGV with identity AGV-A#1 has an on-board UE, which supports dual-3GPP (NR + NR or NR+LTE) access.

Inside the plant, NPN operator NPN-OP#1, which is a PNI-NPN operator, provides coverage and enables AGV-A#1’s connectivity to the private data network in the edge cloud.

AGV-A#1 is equipped with cameras and sensors to collect and report real-time information to the controller in the edge cloud.

A specific traffic policy for AGV-A#1 to access local NPN data network includes the use of MNO-A’s access network when there is no coverage by NPN operator NPN-OP#1 or dual access (home NPN network and MNO-A network) based on QoS requirements.

### 5.15.3 Service Flow

1) AGV-A#1 is inside the plant and within the NR coverage of NPN-OP#1. It is in idle mode.

2) The AGV-A#1 controller in the NPN-OP#1 private network, in the edge cloud, initiates data connection and instructs AGV-A#1 to lift an object nearby and transport it to Loading Area 1.

3) The controller also instructs AGV-A#1 to start real time video streaming, based on which the controller navigates or fine-tunes the navigation of the existing route through the plant. AGV-A#1 is using NPN-OP#1 NR access network to provide real-time video streaming.

4) AGV-A#1 has moved outside by Loading Area 1, where there is a very good signal quality of MNO-A. At the same time, NPN OP#1 small cell is experiencing a surge in capacity demand. To continue providing high-quality video streaming to the remote control system in its data network, AGV-A#1is instructed to split its traffic in a way that video traffic utilizes MNO-A’s access network only and closed-loop commands and feedback messages continue to use home access network, i.e. NPN OP#1.

5) The material is offloaded correctly and AGV-A#1 is instructed to move to Loading Area 2.

6) As AGV-A#1 moves from Loading Area 1 to Loading Area 2, NPN-OP#1 coverage degrades significantly. Streaming video and other services are switched via MNO-A’s network.

7) In Loading Area 2, AGV-A#1 is instructed to collect another object and transport it inside the plant.

8) As AGV-A#1 starts moving from Loading Area 2 to inside the plant, NPN-OP#1 coverage is excellent and the network has ample capacity. Streaming video and other services are switched via NPN-OP#1’s network.

9) AGV-A#1 offloads the collected object to the loading area inside the plant and is instructed to stop the streaming service.

NOTE: Some of the above steps may require collaboration with humans on site, which is outside the scope of this use case.

Diagram

Description automatically generated

**Figure 5.15.2. AGV-A#1 is moving through the factory floor, streaming real-time video and transmitting/receiving closed-loop commands/feedback in the NPN’s edge cloud by splitting and switching/steering traffic between NPN-OP#1 and MNO-A’s access network.**

### 5.15.4 Post Conditions

AGV-A#1 has had reliable access and the required QoS to NPN-OP#1 network (micro)services, e.g. for video-streaming, and closed loop commands and feedback to the controller while moving seamlessly between NPN-OP#1 and MNO-A coverage. It has safely and efficiently transported the designated objects between the loading areas while moving inside and outside the plant.

### 5.15.5 Existing features partly or fully covering the use case functionality

Same as in section 5.3.5 of this TR.

### 5.15.6 Potential new requirements

[PR 5.15.6-001] Based on operators’ policy, the 5G system shall be able to support mechanisms to enable dynamic steering, splitting and switching of a UE’s user data, pertaining to a single data session, between a PNI-NPN and a PLMN, each having a different 3GPP access network, to meet UEs’ QoS requirements when accessing PNI-NPN services, assuming the UE has a subscription with PNI-NPN.

NOTE: The above requirement assumes a proper business agreement is in place between the PNI-NPN and PLMN MNOs, including negotiation of specific traffic routing policies and rules.

## 5.16 Use Case on set of devices accessing local NPN services (inter NPN – PLMN scenario)

### 5.16.1 Description

In many cases, devices operating on the factory floor will be grouped based on their function, location or other characteristics. For example, AGVs may be required to move in groups to transport large or heavy work-pieces cooperatively [TS 22.104]. This next generation of AGVs will have a remote control system, residing in the edge could, guiding them. Such AGVs with a remote controller form a closed-loop system, requiring timely delivery of commands, feedback, and, generally, access to services. The communication link(s) between the control system and AGV must be reliable in both directions. They also need to provide the required QoS in up-link and downlink to ensure AGVs’ safe and efficient operation and enable flexibility of the routes that they may take.

Furthermore, AGVs may be, e.g. moving material from the outside loading areas to the inside of the plant and vice versa. The outside loading area may not be in the immediate vicinity of the plant and, hence, not within the coverage of a PNI-NPN operator. Furthermore, such AGVs may be required to transport the material between multiple sites in a locality where there is limited or no NPN coverage between the sites. Also, the distance between different sites may be too large for an NPN to cover.

This use case addresses a set of infrastructure-assisted AGVs that stream high-quality video. Each AGV has the same QoS and has to move in a coordinated way with other AGVs. They also require, closed-loop control, whereby a central system controller that may be located in the edge cloud controls the drives and movements of each of the AGVs. The communication between AGVs and the control system is bidirectional. The use case addresses the requirement for smooth mobility and high-quality video streaming to the server residing in the NPN’s network, via an MNO’s access network when AGVs are moving in and out of the coverage footprint of NPN.

Finally, it should be possible that, based on the QoS requirements and the conditions of two networks (e.g. availability and available capacity), both networks are utilised so that the data traffic to and from each AGV can be appropriately split or steered.

Diagram

Description automatically generated

**Figure 5.16.1. Loading areas in a vicinity of the plant, where NPN-OP#1 and MNO-A provide 3GPP access networks. Note that loading areas may be located further away from the plant.**

NOTE 1: As stated in TS 22.104, AGVs are a sub-group of mobile robots. In this use case, the term AGV refers to the future generation of AGVs, which can be controlled remotely, e.g. from the edge cloud, enabling flexible route navigation.

NOTE 2: This use case does not preclude the use of UE-UE/Prose communication in addition to communication with the radio access network.

### 5.16.2 Pre-conditions

AGVs with on-board UEs are inside the plant, where NPN operator NPN-OP#1, which is a PNI-NPN operator, provides coverage using 3GPP access network(s), and each AGV’s connectivity to the NPN-OP#1’s data network.

Each UE of each AGV supports dual-3GPP access and dual-radio over the two RATs, and each AGV is equipped with cameras and sensors to collect and report real-time information.

Video streaming is one of the supported services by AGVs. All AGVs have the same QoS requirements for video streaming.

A specific traffic policy for each AGV to access NPN-OP#1 data network includes the use of MNO-A’s access network when there is no coverage by NPN-OP#1, or dual access (home network and MNO-A network) based on QoS requirements.

### 5.16.3 Service Flows

1) A set of AGVs are inside the plant, at an AGV’s stationary point, and within the NR coverage of NPN-OP#1. Each AGV is in idle mode.

2) The controller instructs AGVs to start real-time video streaming to the server in the edge cloud, based on which the controller navigates their movement through the plant and coordinates cooperative carrying. AGVs are using NPN-OP#1 access network to provide real-time video streaming.

3) AGVs have moved outside, by Loading Area 1, where there is an excellent coverage by MNO-A. At the same time, NPN OP#1 is experiencing a surge in capacity demand. To continue providing high-quality video streaming to the remote control system in its data network, the traffic of all UEs is steered to utilize MNO-A’s access network only.

4) The designated material is offloaded correctly and the AGVs are instructed to move to Loading Area 2, while still utilizing MNO-A’s network, as NPN-OP’1s network coverage in this area is poor.

5) In Loading Area 2, AGVs are instructed to collect another object and transport it to the loading area inside the plant.

6) As AGVs move from Loading Area 2 to the inside of the plant, NPN-OP#1 coverage is excellent and the network has ample capacity. Streaming video of each UE is switched to NPN-OP#1’s network.

7) AGVs offload the collected object to the loading area inside the plant and are instructed to return to the stationary point and each to stop the streaming service.

Diagram

Description automatically generated with low confidence

**Figure 5.16.2. AGVs moving through the factory floor and to the outside of the plant, streaming real-time video to the NPN’s edge cloud by splitting and switching/steering traffic between NPN-OP#1 and MNO-A networks.**

### 5.16.4 Post-conditions

All AGVs have had a reliable access and required QoS for video-streaming while moving seamlessly between NPN-OP#1 and MNO-A coverage. AGVs have safely and efficiently moved inside and outside the plant, transported the designated objects to/from the loading areas, moving in a coordinated way.

### 5.16.5 Existing features partly or fully covering the use case functionality

For each UE, same as in section 5.3.5 of this TR.

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

[PR 5.16.6-001] Based on operators’ policy, the 5G system shall be able to support mechanisms to enable dynamic steering, splitting and switching of UE’s user data for one or more UEs across two 3GPP access networks of two different operators to meet service-specific QoS requirements for these UEs, where each UE’s user data pertains to a single data session.

NOTE 1: It is assumed that each UE is accessing the same PNI-NPN services with the same QoS requirements.

[PR 5.16.6-002] Based on operator’s policy, the 5G system shall be able to support mechanisms to enable dynamic steering, splitting and switching of UE’s user data for one or more UEs such that specific service flow(s) use the same access network for all the UEs.

NOTE 2: The above requirements assume a proper business agreement is in place between the network operators, including negotiation of specific traffic routing policies and rules.

## 5.17 Use Case on Vehicle IoT devices steering via NTN and TN

### 5.17.1 Description

For large area agriculture fields and farms where two 3GPP radio access network services are available IoT devices can benefit from dual steering data connection capability of 5G System via NTN and TN access networks simultaneously.

In this use case we have a wide area agricultural automated system of applications controlling agriculture vehicles e.g. a Harvesters retrofitted with hundreds of IoT devices which, connect to TN based access network providing – NR access capable of supporting hundreds of devices in dense population connecting to delay sensitive edge computing applications. At the same time, these devices can also use NTN access which offers connectivity to delay tolerant remote applications.

The dual steering based 5G system provides cost effective solution to autonomously manage the various agricultural operations.

Diagram

Description automatically generated

**Figure 5.17.1. Harvester with IoT devices using both TN and NTN access**

In the figure above:

* Several agricultural vehicles and the agriculture field employ multiple sensors and IoT devices.
* TN and NTN access networks can be managed by the same Network Operator or different Network Operators (with mutual agreement).
* The IoT devices on the vehicle connect to various sensors mounted on the vehicle and/or installed on the terrain the vehicle travels.

### 5.17.2 Pre-conditions

* Alice’s agriculture farm has NR access network and edge computing applications connecting to common 5GC with NTN access network.
* The farm has overlapping TN and NTN radio access coverage.
* The agriculture vehicles on the farm are retrofitted with IoT devices with dual access capable radios and subscription to 5GC PLMN1 (TN).
* These vehicles work in autonomous mode and are operations wise, controlled by sensor data driven applications.
* Both access network providers have agreed, multi-path data traffic routing policies allowing User Data applications to use access networks based on IoT device traffic characteristics.

### 5.17.3 Service Flows

* 1. Alice has to complete various agricultural tasks on the field today.
  2. Alice confirms that multiple vehicles are in operation with the IoT devices, registered on NR PLMN1 and NTN PLMN2 access networks.
  3. The sensors and IoT devices collectively keep sending data over NR to the applications running on local data network. The data sent is time sensitive.
  4. The local edge computing applications analyse the fresh sensor data and prepare specific action plans for the vehicles to perform on the field which include irrigating the crops, determine harvesting routes for the field, collecting samples of the crop from certain part of the field, etc.
  5. The IoT devices also interact with system and exchange configuration, charging and management data with applications hosted remotely. This data is limited in bandwidth and sent to farm vehicles - as needed basis.

### 5.17.4 Post-conditions

At the end of the day, all autonomous vehicles complete various agriculture jobs.

Based on sensors and IoT data the local applications continuously processed, specific actions for the agriculture vehicles are determined and executed.

The overall system configuration, management and charging information is produced and sent to data network.

### 5.17.5 Existing features partly or fully covering the use case functionality

See ATSSS, 3GPP Working Procedures, article 39 and the TSG Working Methods in 3GPP TR 21.900 , including the potential applicability of existing multi-NW requirements (e.g., from TS 22.261 sec. 6.1, 6.3, 6.18, 6.41).

Stage-2&3 include a feature called ATSSS (Access Traffic Steering, Switching, Splitting), e.g., ref to TS 25.301 sec. 5.3.2, which supports functionalities similar to those described in this use case, but limited to 3GPP access plus non-3GPP dual access.

Existing service requirements, e.g., from TS 22.261 sec. 6.3, capture some general multi-RAT connectivity requirements, which do not fully cover or satisfy the specific target use case and functionalities.

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

[PR 5.17.6-001] Based on network providers agreed data routing policies, the 5G system shall be able to support mechanisms to allow splitting, steering and switching of IoT devices data traffic (of the same data session), which is anchored in the 5GC in the HPLMN, across two access networks e.g. NTN and TN.

[PR 5.17.6-002] Based on data usage on both access networks, the 5G system shall be able to collect charging information for the IoT devices.

## 5.18 Use Case on UAV UE connecting to 3GPP TN and NTN access networks

### 5.18.1 Description

In the geographic areas where multiple 3GPP radio access networks and services are available, 5G connectivity can utilize two of the 3GPP data access paths available to the UAV.

In this use case, UAV is with a dual 5G radio capability can connect to 5G System and can get data served via two network access paths, one using terrestrial 3GPP access (e.g. NR) and another using a Non-Terrestrial Network (NTN) 3GPP access (e.g. NR).

When UAV is in flight, in a remote area, the data call session can use one of the two radio access paths or both, depending on coverage availability, type of traffic and QoS.

Diagram

Description automatically generated

**Figure 5.18.1: Illustration of the UAV UE using TN and NTN access**

In the figure above:

* TN / Terrestrial Network coverage is provided by the radio tower on the ground (PLMN1).
* NTN radio network coverage is provided by satellite.(PLMN2).
* Dual 3GPP access combination for the UAV UE includes use of TN+NTN access across PLMN1 and PLMN2.
* The two PLMNs use 5G CN sharing, i.e. 5GC is common across both the TN and NTN networks.
* TN and NTN networks can be managed by the same Network Operator or different Network Operators (with mutual agreement).

### 5.18.2 Pre-conditions

Overlapping TN and NTN radio coverage area.

5G UAV UE with dual radios and dual access subscription to PLMN1.

UE and 5GC support dual 3GPP access functionality via NTN (e.g. Satellite) and TN access.

Relationship of the TN and NTN networks: Scenario 1 - managed by same Network Operator - or Scenario 2 - Multiple Network Operators with mutual agreement. A roaming agreement may also be in place.

Agreed multi-path data traffic routing policy allows to route different traffic over one or different 3GPP access connections, for example FTP file transfers (more delay tolerant) can use one data path while HTTP Video Streaming (requiring higher Tput) can use both concurrent data connection paths.

### 5.18.3 Service Flows

1. Alice launches a UAV application, intended to download terrain maps with identified spots/areas where to capture & upload video/photos, along its path/itinerary. The UE registers on both TN network (PLMN1) and NTN (PLMN2), and starts a dual 3GPP access data connection.
2. Based on configured policies, FTP maps data is transferred via the NTN access network. When the UAV reaches a certain identified location, the UE application begins video streaming / photo capture and start uploading data to the server, using both TN and NTN network connections.
3. Traffic policy can also include the configuration of UE/5GC traffic monitoring and measurements, e.g. packet loss rate, round-trip time (RTT), etc., as well as the possibility to report such measurements (e.g. from UE to 5GC).
4. During this active data session, if/when the UAV encounters degradation on one of the access network paths, e.g. based on configured traffic measurement conditions, UE and 5GC will be able to steer data traffic (both FTP and Video Streaming) over the stronger data access path.
5. Once the radio conditions improve on the impaired radio access network, the dual access data transfer starts again, as in step 2.

Steps 4&5 can repeat during the route.

### 5.18.4 Post-conditions

UE in motion (UAV) gets a suitable data connection on its journey, using efficient steering, switching or splitting of traffic across two concurrent 3GPP access connectivity paths.

### 5.18.5 Existing 3GPP features partly or fully covering the use case functionality

SA1 specs include some existing multi-NW/RAT requirements (e.g. from TS 22.261 sec. 6.1, 6.3, 6.18, 6.41), which do not fully cover or satisfy the specific target use case and functionalities.

Stage-2&3 include a feature called ATSSS (Access Traffic Steering, Switching, Splitting), e.g., ref to TS 25.301 sec. 5.3.2, which supports functionalities similar to those described in this use case, but limited to 3GPP access plus non-3GPP dual access.

There are no service requirements in 22.125 about UAS multi-NW/PLMN support.

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

[PR 5.18.6-001] Based on PLMN operator policies, the 5G system shall be able to support mechanisms to configure and control splitting, steering or switching of UE data (of the same data session) across two 3GPP access networks belonging to two different PLMNs, one of which is the UE’s 5GC HPLMN (e.g. for a UE using single subscription, connected via NR based TN and/or NTN). This can also include support for UE specific user data characteristics measurements (e.g., RTT, Packet loss rate) reporting to UE’s HPLMN.

## 5.19      Use Case on supplementary downlink data via a second 3GPP access network

### 5.19.1    Description

Wireless access in rural areas to users in poor terrestrial access network coverage or radio conditions (e.g. Mountain valley) may not provide the required service performance.

Adding supplementary downlink data capacity (e.g. provided by NTN) would be beneficial to improve the service performance and QoE, for example to support the traffic asymmetry associated to video consumption. Hence, using the downlink capacity of a NTN (GSO Satellites or HAPS) in addition to the available downlink capacity of a base station would enhance the overall downlink performance, especially from a throughput perspective.

Ideally this supplementary downlink data capacity would be provided by a GSO satellite (possibly already in orbit) which would support receive only capability in the terminal.

The figure below depicts the proposed concept.



**Fig. 5.19.1 example of a supplementary downlink data via a second 3GPP radio access network**

Note : In this example, illustrated above, two separate Network Operators are considered. This does not preclude other options/scenarios, as described in later clauses of the document (e.g. same CN).

### 5.19.2    Pre-conditions

Overlapping radio coverage area of the terrestrial and non terrestrial networks.

5G UE with dual radios but a single subscription used to access two different PLMNs (one offering NTN and one TN access).

UE and 5GC support dual 3GPP access functionality via TN access and NTN access.

Relationship of the TN and NTN: Scenario 1 - managed by same Network Operator - or Scenario 2 - Multiple Network Operators with mutual agreement. A service level agreement may also be in place.

Agreed multi-path data traffic routing policy allows to route different data flows of the same service over one 3GPP access connection (via TN or NTN) and a supplementary downlink data via the other 3GPP access connection (via NTN), for example large content or video streaming could be transmitted over the additional downlink connection.

### 5.19.3    Service Flows

1) Alice lives in a remote area where she has a home broadband service (possibly with limited performance), including TV and VoD services, from operator A that is provided through 5G fixed wireless access (FWA) network.

2) When Alice wants to watch VoD service she could experience bad quality connectivity due to the FWA congestion.

3) Operator A is able to provide Alice the VoD service via a supplementary NTN downlink only connectivity.

4) When activating the VoD, the command and control are steered via the TN access while the video stream is steered to the NTN access.

### 5.19.4    Post-conditions

UE will be able to receive high quality video content via the downlink NTN connectivity without impacting the scarce radio resources he may be offered via the TN access network due to its poor radio condition.

### 5.19.5    Existing 3GPP features partly or fully covering the use case functionality

None. ATSSS covers only scenarios of dual connectivity over 3GPP and non 3GPP access.

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

[PR 5.19.6-001] Based on PLMN operator policies, the 5G system shall be able to support mechanisms to configure and control the steering of UE’s service data flows (of the same service session) across two 3GPP access networks (e.g. via 5G terrestrial access network and/or 5G satellite access network), one of which is used for transferring downlink data only. The two 3GPP access networks can belong to one or two different PLMNs, one of which is the UE’s HPLMN, and UE is assumed to use single subscription.

Note 1: The two 3GPP access networks can belong to one or two different PLMNs, one of which is the UE’s HPLMN, and UE is assumed to use single subscription.

Note 2: This can also include support for UE specific user data characteristics measurements (e.g., RTT, Packet loss rate) reporting to UE’s HPLMN.

# 6 Consolidated potential requirements

## 6.1 Introduction

NOTE: The following definition applies for the consolidated potential requirements;   
***DualSteer device:*** *A device supporting traffic steering and switching of user data (for different services) across two 3GPP access networks; it can be a single UE, in case of non-simultaneous data transmission over the two networks, or two separate UEs in case of simultaneous data transmission over the two networks.*

The requirements below cover scenarios and functionalities for supporting enhanced traffic steering and switching of a DualSteer device’s user data (for different services) across two 3GPP access networks, assuming the ability to differentiate the two connections for the same device and minimize impacts to CN, O&M or IT systems.

Target scenarios cover two 3GPP access networks belonging to the same PLMN, or between two different PLMNs, or between one PLMN and one PLMN-integrated NPN, over same or different RAT, which can use terrestrial and/or satellite access (including the case of two different satellite orbits). Scenarios may also include traffic steering and/or switching across LTE/EPC and NR/5GC, with anchoring in 5GC.

Traffic policies are intended to be in full control of the home network operator.

The requirements can apply to different DualSteer device types (e.g., smartphones, IoT, UAV, VSAT devices).

The following assumptions apply:

- a subscriber with two subscriptions/SUPIs, sharing one subscription profile from the same operator;  
- for simultaneous transmission over two networks, a DualSteer device is assumed to include two separate UEs.

## 6.2 General

**Table 6.2-1 – General Consolidated Requirements**

| CPR # | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- |
| CPR 6.2-1 | Subject to HPLMN policy and network control, the 5G system shall be able to support mechanisms to enable traffic steering and/or switching of a DualSteer device’s user data (for different services) across two 3GPP access networks belonging to the same PLMN (either HPLMN or VPLMN), assuming data anchoring in the HPLMN and non-simultaneous transmission over the two networks.  Subject to HPLMN policy and network control, the 5G system may be able to support mechanisms to enable traffic steering and/or switching with simultaneous transmission of a DualSteer device’s user data (for different services) across two 3GPP access networks belonging to the same PLMN (either HPLMN or VPLMN), assuming data anchoring in the HPLMN.  Subject to HPLMN policy and network control, the 5G system shall be able to support mechanisms to enable traffic steering and/or switching of a DualSteer device’s user data (for different services) across two 3GPP access networks belonging to two PLMNs, assuming a business/roaming agreement between PLMN operators (if different), data anchoring in the HPLMN and non-simultaneous transmission over the two networks.  Subject to HPLMN policy and network control, the 5G system may be able to support mechanisms to enable traffic steering and/or switching with simultaneous transmission of a DualSteer device’s user data (for different services) across two 3GPP access networks belonging to two PLMNs, assuming a business/roaming agreement between PLMN operators (if different) and HPLMN data anchoring.  NOTE 1: Inter-PLMN requirements can apply also to PLMN-NPN scenarios assuming a PLMN-integrated NPN (NPN hosted by a PLMN or offered as a slice of a PLMN). | 5.1.6-001  5.2.6-001  5.2.6-002  5.3.6-001  5.4.6-001  5.5.6-001  5.6.6-001  5.6.6-002  5.7.6-001  5.8.6-001  5.9.6-001  5.10.6-001  5.11.6-001  5.12.6-001  5.14.6-001  5.17.6-001  5.18.6-001  5.12.6-001 |  |
| CPR 6.2-2 | For traffic steering and/or switching of user data across two 3GPP access networks, the 5G system shall be able to allow a HPLMN to provide policies and criteria for a DualSteer device to connect to an additional PLMN/NPN, or an additional RAT within the same PLMN. | 5.14.6-001 |  |
| NOTE 2: The above requirements assume configuration of traffic policies, under HPLMN control or negotiated between the HPLMN and other network operators, considering e.g., user subscription, application/traffic type, service preference, QoS requirements, location, time, UE capabilities, mobility, connectivity conditions. | | |  |

## 6.3 Mobility and connectivity changes

Table 6.3-1 – Mobility Consolidated Requirements

| CPR # | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- |
| CPR 6.3-1 | Subject to HPLMN policy and network control, the 5G system shall be able to support mechanisms to minimize service interruption when switching a DualSteer device’s user data, for one or multiple services, between two 3GPP access networks. | 5.2.6-002  5.6.6-002 |  |
| CPR 6.3-3 | Subject to HPLMN policy and network control, for traffic steering and/or switching of user data across two 3GPP access networks, the 5G system may be able to support mechanisms to change one 3GPP access network to the non-3GPP access network of the same subscription (and vice versa). | 5.13.6-001 |  |

## 6.4 Charging and other aspects

Table 6.4-1 – Charging and other Consolidated Requirements

| CPR # | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- |
| CPR 6.4-1 | Subject to HPLMN policy and network control, the 5G system shall be able to collect charging information related to traffic steering and/or switching of a DualSteer device’s user data across two 3GPP access networks.  NOTE 1: Charging information should be collected for both 3GPP access networks; in case the two 3GPP access networks belong to different PLMNs, or a PLMN and NPN, a proper business/roaming agreement among network operators is assumed. | 5.5.6-002  5.9.6-002  5.17.6-002 |  |
| CPR 6.4-2 | Subject to home network operator policy and network control, the 5G system shall be able to support traffic steering and/or switching of a DualSteer device’s user data between a NPN and a PLMN, for one or more a DualSteer devices with a NPN subscription accessing NPN services, to meet specific QoS requirements for each device, assuming non-simultaneous transmission over the two 3GPP access networks.  NOTE 2: The above assumes a NPN hosted by a PLMN or offered as a slice of a PLMN, data anchoring in the NPN, and a business/roaming agreement between the PLMN and the NPN operator (if different) | 5.15.6-001  5.16.6-001 |  |

# 7 Conclusion and recommendations

This technical report analyses several use cases for 5GS support of enhanced mechanisms for steering, splitting and switching of data traffic of a UE’s particular user data session, across two 3GPP access networks. The resulting service requirements have been consolidated in clause 6.

It is recommended to consider the consolidated requirements identified in this TR as the baseline for subsequent normative requirements.

Annex A (informative):  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-08 | SA1#99-e | S1-222210 |  |  |  | TR skeleton | 0.0.0 |
| 2022-08 | SA1#99-e | S1-222280 |  |  |  | Incorporating agreed use cases | 0.1.0 |
| 2022-11 | SA1#100 | S1-223515 |  |  |  | Incorporating agreed inputs | 0.2.0 |
| 2023-02 | SA1#101 | S1-230731 |  |  |  | Incorporating agreed inputs | 0.3.0 |
| 2023-03 | SA#99 | SP-230220 |  |  |  | MCC clean-up for presentation to SA | 1.0.0 |
| 2023-05 | SA1#102 | S1-231340 |  |  |  | Incorporating agreed inputs | 1.1.0 |
| 2023-10 |  | S1-233020 |  |  |  | Incorporating agreed inputs from S1-103, excluding those under WA not approved by SA-101.  Note: this version follows v.1.1.0 (since v.1.2.0 and 2.0.0 were not approved by SA) | 2.1.0 |
| 2023-11 | SA1#104 | S1-233259 |  |  |  | Incorporating agreed inputs | 2.2.0 |