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Title: **Discussion of Integration of Non-3GPP Non-Terrestrial Networks into the 5G Ecosystem**

Agenda Item: 4

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Abstract:

This contribution proposes to analyze the satellite infrastructure as a non-3GPP access opportunity, and which 3GPP standards will need to be modified to fit that model.

1 Discussion

Summary

All the technical analysis, and most of the architecture analysis, related to Non-Terrestrial Networks (primarily satellite) has been focused on the assumption that the satellite system will accommodate 5G waveforms (3GPP node). This assumption eases the storage requirement, processing, and RF burdens on the UE, if the UE is to be able to directly access SATCOM resources. For the many users that regularly utilize satellite resources and terrestrial resources, there has to be considerable flexibility in configuring and managing the switching process and mechanism to ensure only transport networks meeting stringent parameters for reliability, availability, and security are permitted.

3GPP standards exist that address the access and data flow of 3GPP and non-3GPP networks, but there may be issues not addressed in those standards that need to be further studied for a non-3GPP satellite node. This study will analyze the satellite infrastructure as a non-3GPP access opportunity, and which 3GPP standards will need to be modified to fit that model.

5G Terrestrial to non-3GPP Non-Terrestrial Network (NTN) Use Cases

Use Case 1: A user employs a particular terrestrial 5G network to conduct business. The user equipment employed has the necessary security features to transmit sensitive information over a trusted public network. The user equipment supports 5G terrestrial waveforms, as well as satellite communication (SATCOM) waveforms. Without changing user devices, the user purposely selects a 5G terrestrial to specific satellite communications path to communicate with a remote business entity. The 3GPP standards

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facilitate configuring the user device to employ select trusted communication pathways, while excluding others.

Use Case 2: The LEO satellite system provides service to only select private entities. As such it allows access from select base station gateways, or directly from a qualified user device. In this use case, the option to employ the satellite system could be configured several ways through the terrestrial network, such as first available link to the satellite system or for certain types of traffic.

NTN reports and standards work related to non-3GPP satellite links

While most of the Release 15 and Release 16 work to date related to NTN focus on the satellite being a 3GPP node, there are several of the NTN technical reports and technical specifications that do touch on the satellite as a non-3GPP node. In TR 22.822 - Study on using Satellite Access in 5G, the figure below from Appendix A discusses the satellite as a non-3GPP bent pipe, but nothing beyond this as being a potential architecture is discussed [1].

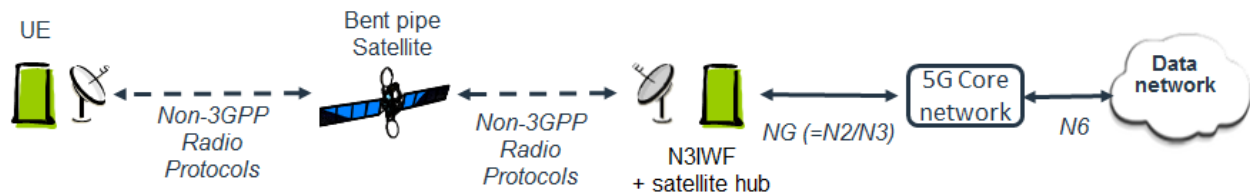


Figure A.7: 5G Satellite access network with a Non-3GPP access network and 5G Core Network [image from 3GPP TR 22.822]

In TS 22.261 – Operational requirements for 5G, there are discussions of requirements for both satellite and non-3GPP components that overlap including multiple access technologies, relay modes, subscription, positioning. It even states the requirement that the radio access network could be a 3GPP or non-3GPP network [2].

In TR 28.808 - System Aspects Study on management and orchestration aspects with integrated satellite components in a 5G network, much of the discussion relates to network slicing and vertical integration. In this case, the management of resources is handled at a higher level and it discusses utilizing the non-3GPP satellite RAN as shown in the figure below [3].

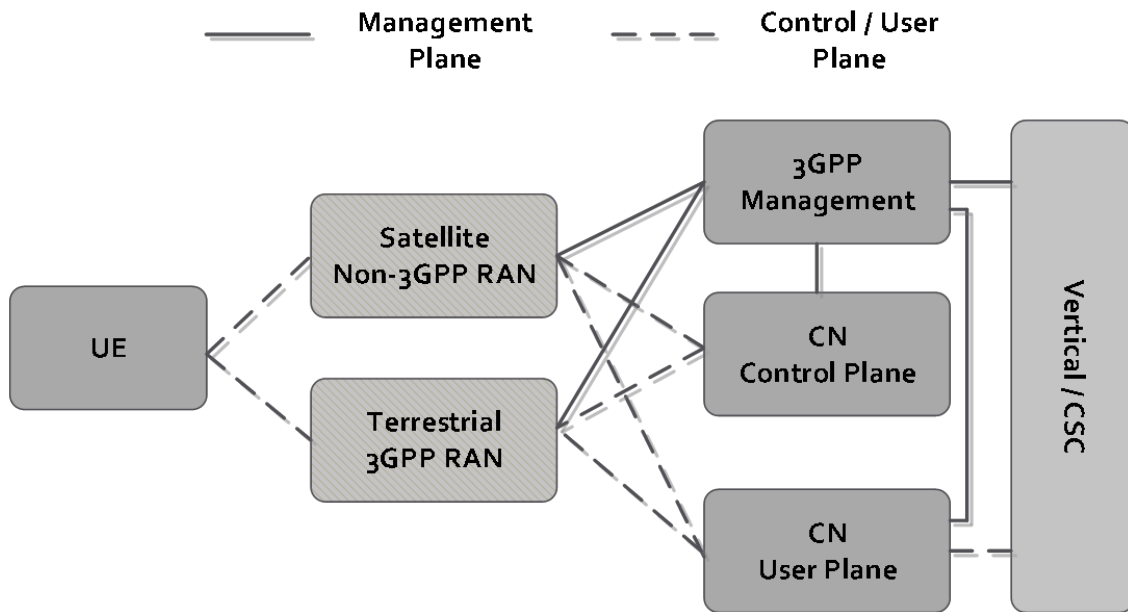


Figure 4.1.2-1: Reference architecture for the management of a non-3GPP satellite RAN [image from 3GPP TR 28.808]

Recently a scenario was added to TR 28.808 as part of SA5 related to the coordination between the satellite and the 3GPP management systems related to non-3GPP. This primarily focuses on the requirements and coordination related to network slicing. A pictorial of the scenario is shown in the figure below[3].

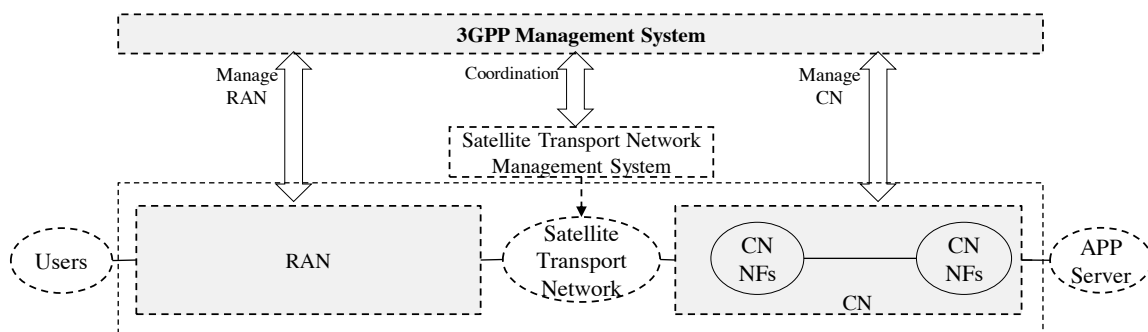


Figure 4.2.3-1: Architecture scenario of 3GPP management system in coordination with the satellite transport network management system [image from 3GPP TR 28.808]

Probably the most detailed information about non-3GPP satellite is discussed in TR 23.737 - Study on architecture aspects for using satellite access in 5G. For Key Issue #7 – multi connectivity with satellite access, the key issue relates to taking advantage of the Multi Access PDU described in TS 23.501. This describes in detail how there is overlap with the Access Traffic Steering, Switching and Splitting (ATSSS) described in TR 23.793 and poses the question whether there is overlap. Solution #4 of the same document proposes following a procedure like those described TR 23.793 but notes that impacts on existing nodes and functionality need further study [4].

Non-3GPP related standards

Much of the work related to non-3GPP access is covered in TS 23.501 (sections 5.32 and 6.3.6), TS 23.502 (sections 4.9.2, 4.11.3 and 4.22) and TR 23.793. Also, the Wireless Broadband Alliance is working closely with the 3GPP community which overlap some of the work being done in the standards bodies [5][6].

TS 23.501 - System architecture for the 5G System (5GS) discusses connectivity and services. Specifically related to non-3GPP, it focuses on the ATSSS and the Non-3GPP Interworking Function (N3IWF). For ATSSS, it covers multi access PDU, policy, QOS, network performance measurements, steering, the EPS, and rules. For N3IWF, it covers the interworking between non-3GPP related to selection [7].

TS 23.502 - Procedures for the 5G Systems discusses the PDU Handover procedures for 3GPP and non-3GPP, handover procedures between EPS and N3IWF and ATSSS procedures [8].

Finally, TR 23.793 - Study on access traffic steering, switch and splitting support in the 5G system architecture was a study focusing on the key issues and proposed solutions that made recommendations for changes to standards TS 23.501 and TS 23.502 based on this work. This report lays out the high-level architecture for 3GPP and non-3GPP access as shown in the figure below. Also, the protocol stack is shown for 3GPP and non-3GPP to understand at what layers different parts of the 5G infrastructure communicate [9].

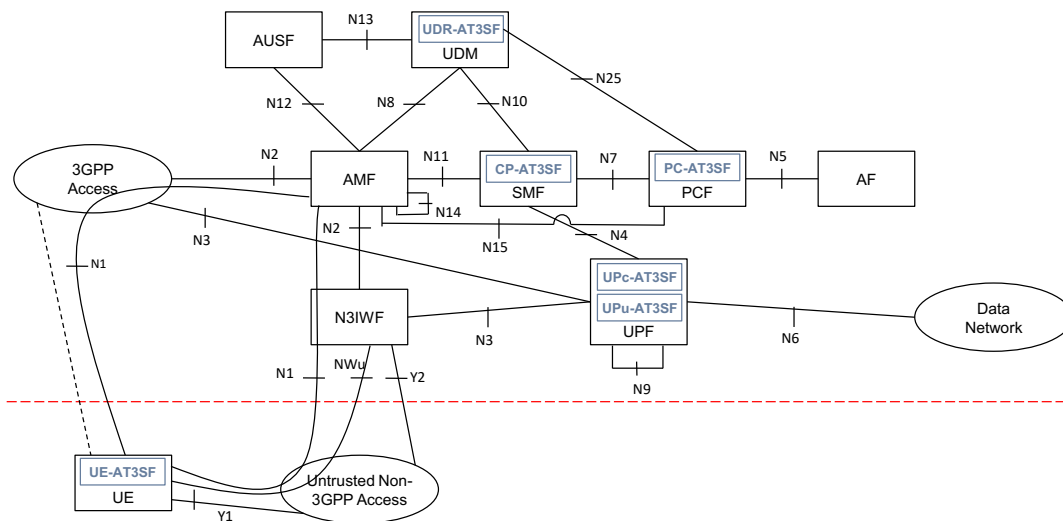
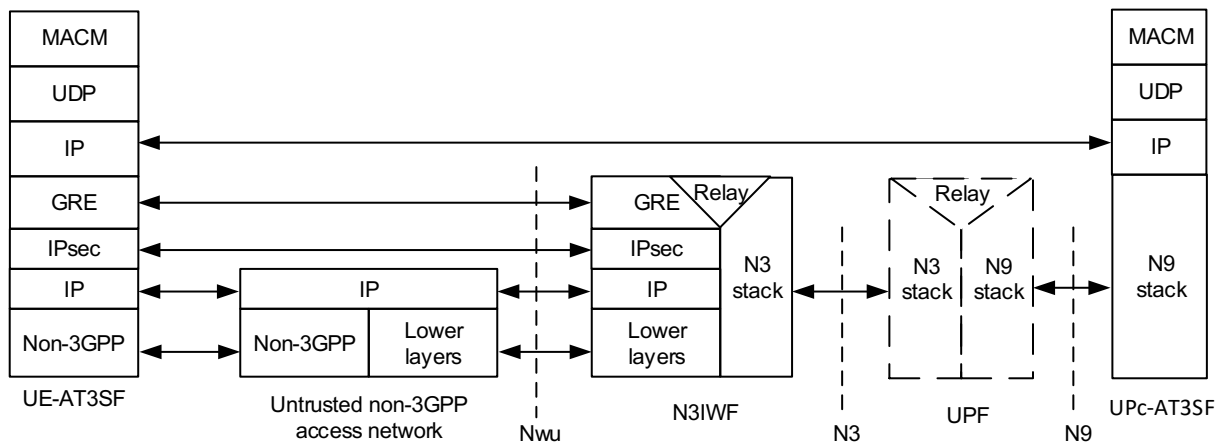
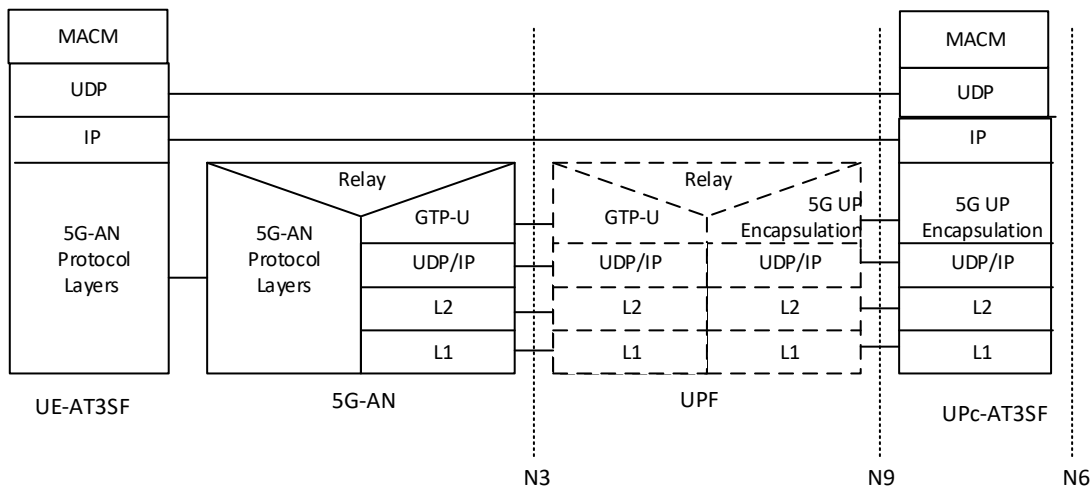


Figure 6.1-1: Initial high level view of non-roaming ATSSS architecture [image from 3GPP TR 23.793]



a: UDP based Control Plane Protocol Stack over non-3GPP access



b: UDP based Control Plane Protocol Stack over 5G-AN

Figure 6.1.6-1: Control Plane Protocol Stack between UE-AT3SF and UPc-AT3SF [image from 3GPP TR 23.793]

Why the non-3GPP route

There are several reasons why this is an area worthwhile studying.

- Almost all modern devices support more than one waveform or protocol, and devices already do some level of switching in 4G; hence, it is likely that this switching technology will be widely available and distributed.
 - Questions remain on the level of complexity of the waveforms related to processing, batter consumption related to adding another waveform to the user device, but the switching process will be the same, nonetheless.
- Rather than tightly integrating the satellite system with 5G, pursuing a combined 5G and non-3GPP ecosystem provides greater flexibility in accommodating more efficient satellite waveforms. All current and known proposed satellites use non-3GPP waveforms.
 - As stated above, moving the complexity from the satellite to the handset will need further study

- This approach should be pursued in parallel to the more integrated NTN options that rely on the satellite network being an integrated part of the 5G network. That way, either approach can be supported in the future
- Accommodating satellite systems as non-3GPP systems provides a bridging alternative for satellite systems planning on integrating the 5G waveform in the future. This could be a steppingstone to integrate in satellite networks into the network at higher levels (non-waveform) prior to satellite vendors investing in making their satellites and networks 3GPP compliant.
- Including special purpose satellite systems as non-3GPP systems provides organizations greater flexibility and autonomy in the employment of a more capable 5G ecosystem that can accommodate purpose-built waveforms, equipment, or infrastructure. By providing a standardized way to integrate non-3GPP satellites into the 5G infrastructure, organizations can specify future satellites, terminals and other support equipment follow these protocols when building their systems.
- Standardizing the ability to efficiently switch between 5G and non-3GPP systems benefits organizations by more easily allowing the integration of viable legacy systems. Potentially, upgrades to ground equipment can allow these networks to be part of the 5G infrastructure.

2 Proposals

There are several standards that touch on both non-terrestrial networks and 3GPP/non-3GPP internetworking. Based on this fact, there may be several areas where this study can have impact on modifying standards related to supporting non-terrestrial networking. The first area this study will address relates to the satellite architecture standards of 3GPP SA2. Currently the standards focus on two primary architectures. The regenerative (satellite is a gNB) or transparent (satellite repeats the 5G waveform and the gNB is on the ground) architectures. Both cases support a 3GPP 5G waveform being sent and received by the satellite. We propose a third architecture where the satellite transmits any waveform and the integration of the satellite network is done at higher layers following the ATSSS architecture shown in figure 6.1.3.1 shown earlier. We recommend proposing a Key Issue, and one or more Solutions to Technical Report TR 23.737 - Study on architecture aspects for using satellite access in 5G – (Release 17).

We also propose a new steering mode or functionality to TR 23-700-93 - Study on Access Traffic Steering, Switch and Splitting support in the 5G system architecture Phase 2 (Release 17). This would integrate the satellite as another possible non-3GPP node not previously addressed in this or previous studies.

If these items were incorporated, it may lead to changes in other standards including the following and other TBD standards.

- There may be impact to TS 22.261 – Operational requirements for 5G. There are discussions of requirements for both satellite and non-3GPP components that overlap including multiple access technologies, relay modes, subscription, positioning that may be affected.
- There may be impact to TS 23.501 - System architecture for the 5G System (5GS). Specifically related to non-3GPP, it focuses on the ATSSS and the Non-3GPP Interworking Function (N3IWF), but as stated earlier, this does not address the

aspects of the satellite as a non-3GPP node which may necessitate changes to support this capability.

- As in TS 23.501, there may be impact to TS 23.502 - Procedures for the 5G Systems. The standard discusses the PDU Handover procedures for 3GPP and non-3GPP, handover procedures between EPS and N3IWF and ATSSS procedures which may be impacted when considering the non-terrestrial network as a non-3GPP node.

3 References

- [1] 3GPP TR 22.822 - Study on using Satellite Access in 5G; Stage 1
- [2] 3GPP TS 22.261 - Service requirements for the 5G system; Stage 1
- [3] 3GPP TR 28.808 - Study on management and orchestration aspects with integrated satellite components in a 5G network
- [4] 3GPP TR 23.737 - Study on architecture aspects for using satellite access in 5G
- [5] Wireless Broadband Alliance 5G Workgroup - Unlicensed Integration with 5G Networks
- [6] Wireless Broadband and Next Generation Mobile Network Alliance - RAN Convergence Paper
- [7] 3GPP TS 23.501 - System Architecture for the 5G System; Stage 2
- [8] 3GPP TS 23.502 - Procedures for the 5G Systems; Stage 2
- [9] 3GPP TR 23.793 - Study on access traffic steering, switch and splitting support in the 5G system architecture
- [10] 3GPP TR 23.700-93 - Study on Access Traffic Steering, Switch and Splitting support in the 5G system architecture Phase 2