5G and Satellite Network Convergence: Survey for Opportunities, Challenges and Enabler Technologies

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***Abstract*—Development of 5G system as a global telecommunication infrastructure is accelerating to realize the concept of a unified network infrastructure incorporating all access technologies. The potential of Low Earth Orbit (LEO) constellation systems has emerged to support wide range of services. This could help to achieve 5G key service requirements for enhanced Mobile Broadband (eMBB), Massive Machine-Type Communications (mMTC), and Ultra-Reliable Low-Latency Communication (URLLC). The integration of satellite communications with the 5G New Radio (NR) is stimulated by technology advancement to support challenging service requirements and demand for ubiquitous connectivity with the best possible quality of service. In this paper, we surveyed the opportunities of integrating terrestrial mobile and satellite networks, key technical challenges and proposed solutions. We also introduced a mobility management scheme that reduces signaling overhead and minimizes service interruption during inter satellite handover process.**

***Index Terms*—5G NR, Terrestrial Mobile Networks, Satellite Networks, Mobility Management.**

I. Introduction

In the past few years, there has been a surge of proposals about using large constellations of Low Earth Orbit (**LEO**) satellites, such as OneWeb and SpaceX [1], to provide broadband access. Satellite services combined with fifth generation (**5G**) mobile telecommunications can take advantage of extensive service coverage to provide 5G services in cost-effective ways especially in areas where terrestrial mobile network services are vulnerable. It is anticipated that the integration of satellite communications into 5G will facilitate anything, anytime, anywhere connectivity in the 5G era and beyond. The 3rd Generation Partnership Project (**3GPP**), which develops the 5G mobile communication standards [2], considers Non-Terrestrial Networks (**NTN**) including satellite services as one axis of the expansion of the 5G ecosystem [3]. The ongoing standards development provide a unique opportunity to study satellite communications as a new area of exploration. The above shows that a group of satellites in low orbits that are working all together as a communication network are imagined to be an appealing solution to extend the 5G New Radio (**NR**) and beyond 5G communication systems [4]. In this paper, we conducted a comprehensive survey on the integration of satellite into terrestrial mobile networks. In Section II, we explored opportunities and potential use cases, then we discussed in section III basic characteristics of satellite communication and challenges facing satellite and terrestrial mobile networks convergence in section IV. Covered challenges include long propagation delay, high Doppler effect, base station movement, re-transmission, spectrum aspect and mobility management. We surveyed proposed architectures in the literature, classified the taxonomy of researches on satellite and terrestrial mobile networks. In section V, we introduced a mobility management scheme. We conclude our work in Section VI.

II. Opportunities and Use Cases

5G comes with the aim to enable a truly connected world by connecting everyone and everything together delivering higher data rates, extremely low latency, improved reliability and greater capacity. The 5G wireless access is being developed to support three main use cases: enhanced Mobile Broadband (**eMBB**), Ultra-Reliable and Low-Latency Communications (**URLLC**), and Massive Machine-Type Communications (**mMTC**).

Integrating satellite communications into 5G networks provides great opportunities. The satellite communication networks with its wide coverage, ubiquity and high scalability can play a crucial role in enabling the 5G use cases. It can provide 5G global connectivity at affordable cost specially in the rural and remote areas where the terrestrial networks deployment could be economically challenging.

3GPP has identified 12 potential use cases for satellite access in 5G that can be grouped into 3 major service categories as defined in TR22.822 [5] and further illustrated in [6] [7]. The 3 main service categories are service continuity, service ubiquity and service scalability as summarized below:

- *Service Continuity*: While terrestrial networks can provide reliable coverage in urban areas, service continuity can't be guaranteed across the globe by the terrestrial networks solely where coverage gaps may exist in some geographical areas. This category of use cases target to increase the 5G service reliability by providing the 5G users (e.g. cars, trains, airborne platforms, maritime vessels) with continuous access to services granted by the 5G system.
- *Service Ubiquity*: Terrestrial coverage may not be available in some rural and remote areas. Terrestrial network services can be either temporarily interrupted or totally destructed by natural disasters. This category of use cases

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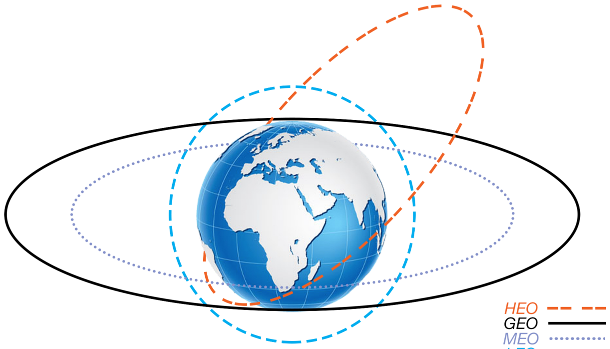

Fig. 1. LEO, MEO, GEO & HEO Illustration.

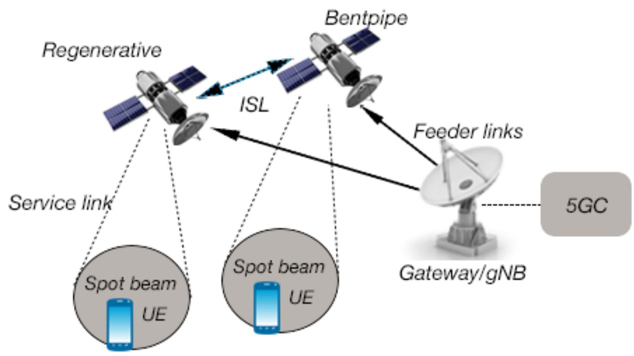

Fig. 2. Network Architecture with both bent-pipe and regenerative satellite systems.

target to provide 5G services through satellite access networks in such unserved or under-served areas.

- *Service Scalability*: This category of use cases would support the 5G network scalability by efficiently utilizing the satellite network capabilities in the multicasting and broadcasting of data such as the distribution of ultra high definition TV content.

In addition to the use cases analyzed by 3GPP in [5], authors of [6] have mentioned autonomous ships as a potential use case with strict requirements for communication latency and uplink connection. Also [8] has mentioned some high potential use cases for connected vehicles as a new vertical market.

III. Satellite Communication Characteristics and Architecture

Satellite communication, usually in the simplest form, is a wide flying object that reflects signal from one point on the planet to another. It uses what is called "Transponder" that listens to a certain frequency range and transmits in another one.

The Orbits are different from the prospective of distance, latency, shape and relative speed to earth as seen in Table I, with the main ones are Geo-stationary Earth Orbit (**GEO**), Low Earth Orbit (**LEO**), Medium Earth Orbit (**MEO**), Highly Elliptical Orbit (**HEO**) [9] [10] [11] as seen in "Fig. 1". The orbits are limited and considered a scarce resource. In the future, they are expected to have more standardization involvement in the inter-orbits combined communications [12].

TABLE I
Orbits different Aspects.

Aspect	*LEO*	*MEO*	*GEO*	*HEO*
Distance	400-2,000 km	8,000-20,000km	35,786km	1,000(Perigee)-40,000(Apogee) km
Latency	Small	Small	Long	Very Long
Orbit Shape	Nearly Circular	Nearly Circular	Nearly Circular	Elliptical
Rel. Speed	High	Low	Stationary	Varying

The network/constellation size can be different but surely it could decrease as we go higher in altitude as the coverage increase. Different antenna types are used to provide a small footprint & high power *"Spot-Beams"* or wider footprint *"Large/Flood-Beams"*. Also different antenna sizes are used depending on the applied frequency/wavelength ($DishDiameter \propto 1/\lambda$). Satellite systems have exclusive competences in terms of broad coverage, robustness, broadcast and multicast capabilities. On the other hand, it has many challenges related to propagation like indoor, weather issues, delay, path loss and mobility management. Major challenges are discussed in the next sections along with the proposed solutions, and technological enablers.

A. Satellite System Architecture

Satellite access typically features the following system elements as in "Fig. 2", [13] [14]:

- *Terminal*, whether User Equipment (**UE**) for terrestrial or satellite mobile system.
- *Terrestrial Gateways*, that connect the satellite network to the infrastructure of core network whatever its form.
- *Service/Feeder Links*, that link between the user equipment and the satellite or between the satellite and the terrestrial gateway.
- *Satellite*, equipped for satisfying a configuration to implement either a bent-pipe or a regenerative relaying radio signal in what is called as *spot-beam*.
  - *Bent-pipe Configuration*: It is a set of actions been applied including filtering, conversion and amplification of Radio Frequency (**RF**) as a *Relay Mode*.
  - *Regenerative Configuration*: Same as Bent-pipe but as it could be the same as 5G base station (**gNB**) it could do demodulation/decoding, apply a possible predefined decision, then coding/modulation. [5] [7].
- *Inter-Satellite Links (**ISL**)*, which will be used mainly in the predefined decision making configuration and the existence of a satellite constellation for routing optimization. ISL connections implementation can use normal RF [15] or Free-Space Optical (**FSO**) [16] communication technology that uses light propagating in free space for transmitting data as will be mentioned later.

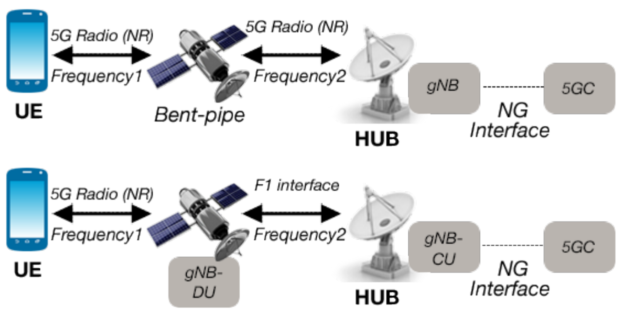

Fig. 3. 3GPP 5G communication architectures evolved with satellites. [2]

B. Satellite and 5G NR Network Architecture

As in "Fig. 3", the existing 3GPP communication architectures evolved with satellites [2]. In the proposed architectures, regenerative satellites with on-board processing abilities and bent-pipe satellites, which have no on-board processing capabilities, are depicted in the 5G satellite access networks respectively.

IV. Challenges and Enabler Technologies

Satellite communication systems are facing many challenges that need to be tackled to achieve the required performance objectives. In this section we will explore the major challenges and state of the art technologies/solutions proposed to mitigate performance implications and facilitate the integration of satellite and terrestrial mobile networks.

A. High Propagation Path Loss

Link budget is an aspect for satellite links, it is affected by the available power, Signal-to-Noise Ratio (**SNR**), antenna gain and sensitivity at both ends of the communication. According to [17] [18], the power at the receiver is a factor of source power, distance, the antenna characteristics at both sides, and free-space attenuation L_{bf} "(1)".

$$L_{bf} = 20 \log_{10} \left(\frac{4\pi . d}{\lambda} \right) \tag{1}$$

To alleviate the access problem, innovations like beamforming are introduced into integrated satellite-terrestrial mobile networks to improve coverage and serve multiple users.

Many beam management methods have been introduced in [19], it proposes way to use the configuration of common Transmission Configuration Indicator (**TCI**) to reduce beam measurements, reporting and application procedures to make use of the same NR beam management.

While [20] proposes the satellite to act as a relay, in a two-way Amplify-and-Forward (**AF**) based transmission between several multi-antenna earth stations to use a mix of different scheme combinations with the beamforming. To avail successful satellite and terrestrial mobile terminal communication, interference level should be reduced using different techniques. Authors in [21], highlights the efficient use of digital processing technologies in applying the phased-array beamforming to optimize the spectrum resources efficiently and to ensure interference free and flexible spectrum sharing.

Satellite coverage also has low building penetration loss due to long traveled distance especially for higher frequency band. Authors in [22] proposed that coordination between satellite and terrestrial mobile network is considered as a good solution for this specific problem.

B. Spectrum Scarcity

RF spectrum is regarded as a limited natural resource. There are several frequency bands allocated for the satellite communication (ranging from 1-40GHz) that have multiple use cases as illustrated in Table II [9] [23]. 5G terrestrial mobile networks with the requirement to deliver significantly faster data speeds and greater capacity to support the eMBB services will need to utilize the millimeter (mm) wave band which is already utilized within satellite networks.

In the World Radio Communication conference 2019 (**WRC-19**), it has been agreed on the use of the frequency bands (24.25-27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 and 66-71 GHz) for 5G networks worldwide. In the same conference, the bands 45.5-47 and 47.2-48.2 GHz have been assigned as supplementary bands for use by most of the nations except for some countries due to band use occupation already on a national level [24].

TABLE II
SATELLITE FREQUENCY BAND

Band	***Freq. Range***	***Usage***
L-Band	1-2 GHz	Mobile Satellite Service (**MSS**), Radio-Navigation Satellite Service
S-Band	2-4 GHz	Radars, MSS, Broadcasting Satellite, Space Research
C-Band	3.4-7 GHz	Fixed Satellite Service (**FSS**) ,VSATs ,Direct-To-Home (**DTH**)
X-Band	7-10 GHz	Radars, Satellite Imaging, Space Research
Ku-Band	10-15 GHz	FSS ,VSATs ,Broadcasting Satellite ,MSS
Ka-Band	17.7-21.2,27.5-31 GHz	FSS "Broadband",Inter-Satellite Links ,MSS

Worth to mention, Cognitive Radio (**CR**) is an intelligent radio and network technology that is being used in satellite networks for efficient spectrum utilization. It's a hot research topic where several techniques for spectrum usage optimization, spectrum database technologies and Machine Learning (**ML**) techniques are being used in smart cognitive satellite communication networks as surveyed in [25].

C. Satellite Propagation Delay

Latency has been a problem in satellites, due to large distance to earth. Also the elevation angle α is an indirect factor in the overall delay as it affects travelled distance "(2)" [13], and in Table III it was assumed to be $\sim 10 - 30deg$.

$$d = \sqrt{r_E \sin^2(\alpha) + H^2 + 2Hr_E \sin(\alpha)} - r_E \sin(\alpha) \tag{2}$$

Propagation delay is proportional to the distance a signal needs to travel in the atmosphere as shown in Table III [13] [14].

The use of LEO satellites can lower the delay compared to GEO and MEO constellation because of shorter distance between terminal and satellite. Moreover, latency can be reduced through innovative solutions in other parts of the protocol

TABLE III
SOME EXAMPLES OF PROPAGATION DELAY

Orbit	*Propagation Delay (One-Way)*
HEO	$\sim 13- \sim 137ms$
GEO	$\sim 137ms$
MEO	$\sim 48ms$
LEO	$\sim 6.4ms$
UAS	$\sim 0.8ms$
Terrestrial Tower	$\sim 0.03ms$

stack. For example, different TCP acceleration techniques are being used to tweak TCP parameters in a way that proved to reduce impact of high latency on overall system performance [26]. To overcome this long delays, 5G NR needs to tweak Random Access and Hybrid Repeat Request processes to cope with satellite longer delay as described in the following two subsections.

*1) Hybrid Automatic Repeat Request (**HARQ**):* To overcome transmission errors, 5G NR uses HARQ which is a combination of forward error correction and Automatic Repeat Request (**ARQ**). Forward Error Correction (**FEC**) coding adds parity bits to the information bits, enabling error correction at the receiver. The receiver sends a positive acknowledgement if no error is detected in the received packet and a negative acknowledgement otherwise. A substantial throughput degradation could occur while using the stop-&-wait protocols implemented by the HARQ processes. So, increasing the number of HARQ processes to cope with the high round trip delay in satellite communications systems is an option but with a cost of increasing the UE design complexity. Another option is to turn off retransmissions in HARQ and handle retransmissions by the layers above Media Access Control (**MAC**). Also, to prevent unnecessary retransmissions, the communication system may need to operate at a more conservative physical layer coding rate.

2) Random Access: Different UEs need compensation for different propagation delays to ensure that they are time aligned at the gNB, this is achieved through using different timing advance values.

The Satellite system propagation delay is greater than the longest length Cyclic Prefix (**CP**) of terrestrial mobile Physical Random Access Channel (**PRACH**) formats. In [14], to overcome that limitation a proposed approach depending on the UE complexity was discussed. For which the high-end UEs with any type of Global Positioning System (**GPS**) chipsets will formulate the initial timing advance using its position and propagation delay, while other UEs allow the gNB to choose a reference point in each spot-beam that the timing of the CP of the Uplink (**UL**) receiver can be adjusted within the available limit of 1.37ms with respect to the selected point. Those issues leverage the need to have a direct satellite to satellite connection for large area crossing which is better than the existing connections as concluded from simulations in [27]. This kind of connection is expected to be laser connection FSO as in Starlink constellation [28]. Also, as illustrated by the author of the above mentioned simulation visually in [29], it would be better to mix between relaying stations whether a satellite or terrestrial, specially in mega-satellites constellations with long distance connections.

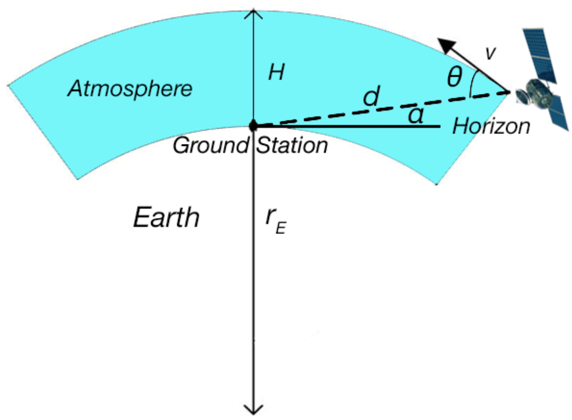

Fig. 4. Doppler effect in LEO.

D. Doppler Effect

To highlight the Doppler effect in “Fig. 4” that is caused by the LEO speed effect with speed difference between space objects and the terrestrial stations leading to change in carrier frequency f_c as seen in “(3)” ,“(4)” and Table IV [30] [31]. The magnitude of carrier shift depends on the relative speed of motion and the carrier frequency. Doppler compensation techniques need to be implemented to reduce its impact on system performance. Authors in [14] proposed a pre-compensation technique relying on Global Navigation Satellite System (**GNSS**). The technique can be applied so that a predefined Doppler compensation value could be applied on the signal at a reference point to have zero Doppler shift. Still authors in [32] consider the atmospheric layers as another factor to be considered in the doppler effect. Using that change will help in the forward link compensation for the Base-station to Satellite or Satellite to UE.

$$f_k = f_c \left(\frac{\sqrt{1 - \frac{v^2}{c^2}}}{1 - \frac{v}{c}\cos(\theta)} - 1 \right) \tag{3}$$

$$v = \sqrt{\frac{\mu_G}{r_E + H}} \tag{4}$$

V. MOBILITY MANAGEMENT

In contrast to GEO satellite systems, LEO satellite systems have a number of advantages, such as efficient bandwidth usage, lower propagation delays, and lower power consumption in the user terminals and satellites. However, a LEO satellite’s coverage area over the earth surface is not fixed due to the satellite’s asynchronous motion relative to earth resulting in recurring handovers when connecting with LEO

TABLE IV
DOPPLER EFFECTS PARAMETERS

Symbol	*Parameters*
f_c	center frequency of $T_x signal$
r_E	Earth Radius (6357km)
H	LEO Sat. height (340km)
(μ_G)	Gravitational constant multi. by earth mass
c	speed of light
θ	Angle between Sat. direction and ground station
d	LEO Sat. distance to ground station
α	elevation angle over the horizon

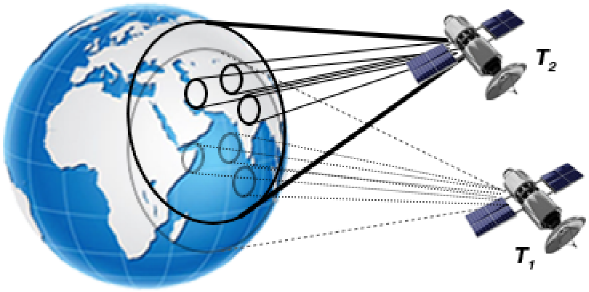

Fig. 5. SFC System, show the fixed cell relative to the satellite. [15]

constellations. Therefore, mobility control is more difficult in LEO satellite systems than in GEO systems. The same difference exists when comparing mobility management in LEO system to terrestrial mobile networks. Challenges in location management (registration and paging) will also arise because of frequent handovers and re-selections due to the movement of satellites. In the coming sections we will survey the proposed coverage and handover/re-selections techniques in literature and introduce a mobility scheme that govern handover/re-selections between different satellites and between satellite and terrestrial mobile networks.

A. Coverage Scenarios

As LEO satellites pass over the same area on earth, they are visible for a few minutes [14] ; therefore frequent handovers take place between different satellites to achieve continuity. The satellite coverage footprint is typically split into smaller cells or spot-beams to achieve efficient frequency reuse. Taking into consideration the physically spacing between spot-beams, an optimized spectrum utilization could achieve minimum interference with the frequency reuse patterns [33]. This allows a number of spot-beams and/or satellites to serve a UE during a connection life cycle. Satellites beams can be designed from coverage perspective into Satellite Fixed Cell (**SFC**) and Earth Fixed Cell (**EFC**). [15] [33]:

- *Satellite Fixed Cell (**SFC**) Systems*: Beams are Satellite related, where the beams' fixed directions are maintained while the satellite is moving steadily over the earth as in "Fig. 5".

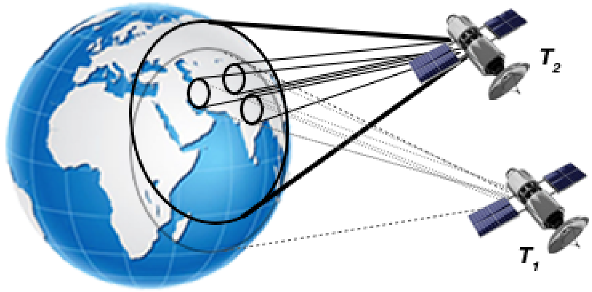

Fig. 6. EFC System, show the fixed cell relative to earth. [15]

- *Earth Fixed Cell (**EFC**) Systems*: Beams are Earth related, where the beams' direction changes to match the fixed cells on the ground during the satellite movement as in "Fig. 6".

B. Literature Review for Mobility Management in Satellite Networks

Handover (HO) refers to the process of transferring an ongoing call or data session from one logical/physical channel to another with minimum loss or interruption of service. This can involve different terrestrial stations and/or satellites. When a serving satellite cannot sustain its connection due to a fall in the signal level below the fading margin, satellite handover happens (The user can be going out of satellite's sight for example). For that, the connection should continue with the next available satellite. Communication system performance greatly depend on handovers performance as unsuccessful handover results in call/data session blocking and forced call termination.

Different layers of network protocol stack could be involved in HO process. The lower the layers involved in handover preparation, coordination and execution the better the performance and lower interruptions that could be achieved. Based on this, handover could be classified into link layer handover or network layer handover. In satellite systems, there are several types of link layer handovers: [33]: (a) *Satellite HO* is moving a connection from a satellite to another one, (b) *ISL HO* occur when ISL relocation is needed as a result of the satellites position change, and (c) *Spot-Beams HO* is an intra-satellite HO with the only change is moving over the connection to a different spot-beam. Further ISL classification can be seen in "Fig. 7":

- *Intra-plane ISLs* which connect satellites within the same orbit, in this case the relative location of the neighboring satellite remains fixed and can easily use FSO for connectivity.
- *Inter-plane ISLs* which connect satellites in adjacent orbits, in this case the relative location of the neighboring satellites changes with time making the FSO connection more complex.

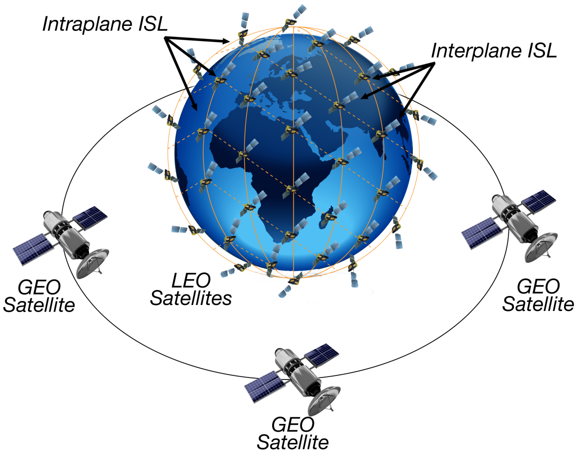

Fig. 7. Inter-Satellite Links Handover. [33]

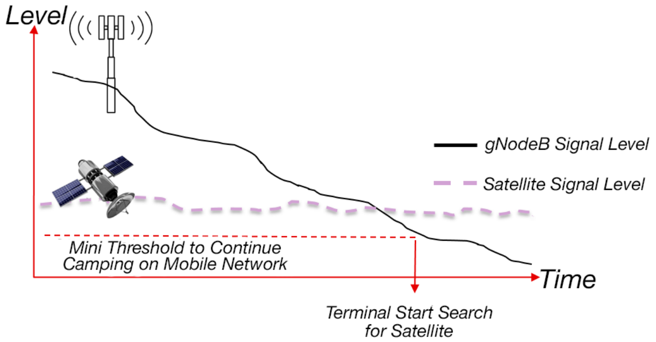

Fig. 8. 5G-Satellite Handover.

Standardization entities might haven't started addressing inter-orbits interworking yet. However, service steering to different satellite layers (LEO, MEO and GEO) could be needed to serve different type of services based on its performance requirements. For example, broadcast service could always be steered to higher satellite layers (GEO or MEO) whenever possible to free up precious resources on LEO layer. Integrating satellites and terrestrial mobile networks will require roaming between both networks to achieve the main purpose of total coverage around the globe. In such an environment, a dual mode terminal can allow uninterrupted service by handing over from one segment of the network to another. This introduces a new Inter-Technology Handover where handover from satellite system to a terrestrial mobile network is needed in both directions. So far, only physical link layer (*Layer1* or *Layer2*) have been addressed in the Non-Terrestrial network handover. But considering Network Layer (*Layer3*) handover is a must as the common routing protocols where the UE or Satellite Internet Protocol (**IP**) address might need to be changed with Routing Area (**RA**) change, or to update the satellite routing tables as the direct neighbour nodes/hops might change frequently. Coordinating traffic flow on IP layers is needed between different access nodes in satellite or terrestrial mobile network for both link layer and IP layer types of handover. In [21], the author propose a smoother way of handling the handover from the latency, throughput and connection quality perceived by the end user point of view; through applying Software-Defined Networking (**SDN**) architecture. Authors in [34] have reached an acceptable HO delay (400ms) for multimedia services by suggesting a Session Initial Protocol (**SIP**) based scheme for soft HO. Additionally, the criteria on which handover decision is based have been thoroughly studied in the literature. Authors in [35] took the Quality-of-Service (**QoS**) only as the handover criteria, in this proposal the user will not be denied from performing the handover if he can lower the required QoS. Mapping how a terrestrial mobile network HO work based on the signal characteristics, authors in [36] have proposed to implement the same on satellite signal where the received signal strength from different sources are used for HO decision.

C. The Proposed Mobility Scheme

To mitigate impact of frequent handovers/re-selections in satellite networks, we propose adopting different types of handover according to the following scheme:

- Use EFC "Fig. 5" where the mobile terminal will receive the same Tracking Area Identity (**TAC**) broadcasted (Used by terrestrial cells) during satellite coverage, this will reduce the amount of signaling overhead.
- Wherever terrestrial mobile network coverage exist, HO should be performed from satellite to terrestrial mobile network to free satellite resources. Mobile terminal can start search for satellite signal only if terrestrial mobile network power level falls below certain threshold "Fig. 8".
- To guarantee smooth handover/re-selections for terminals camping on satellite cells during the satellite visibility period, the broadcasted system information for neighbor cells, idle mode and connected mode parameters controlling mobility can be used to allow terminals to start measure overlapping cells transmitted by the neighbour satellite on different frequencies as "Fig. 10". Measuring cells transmitted by neighbour satellite should only start if serving cells power level falls below certain threshold "Fig. 9". This will ensure 100% service availability without interruption. However, constellation design must consider resource overhead during satellite switching time as two satellites will be serving the same area at the same time.
- When the requested service matches the requirement of a higher satellite constellation, a satellite layer HO needs to be performed.
- Additionally, the use of SDN and FSO between Intra-Plane satellites will allow to clone the spot-beam parameters between neighboring satellites so that despite having an ISL HO, the serving spot-beam remains unchanged from the mobile point of view.
- The opportunity of creating a unique Public Land Mobile Network (**PLMN**) setup, which include an interworking

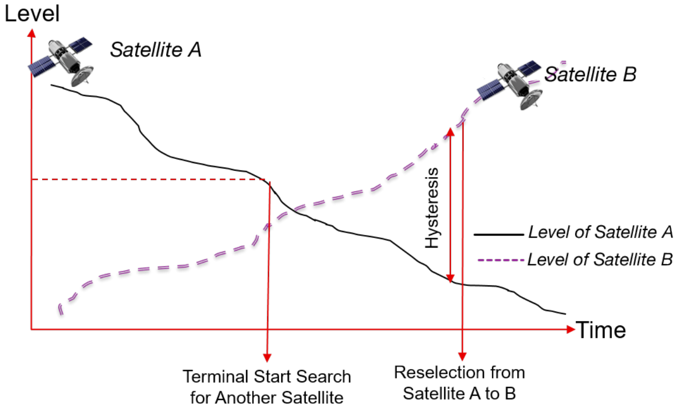

Fig. 9. Terminal Re-selection Mechanism Between Two Satellite.

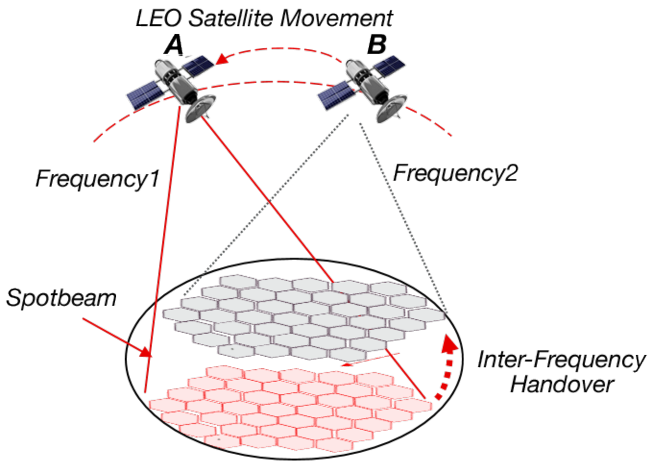

Fig. 10. Overlapping Coverage Between Two Neighbor Satellites.

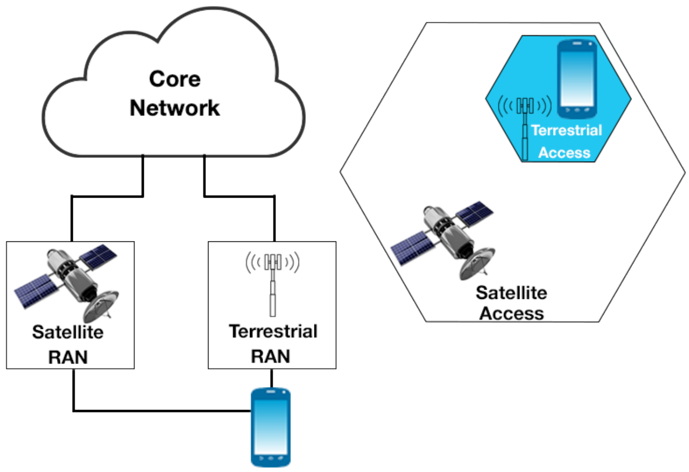

Fig. 11. Satellite and Terrestrial mobile RANs within a single PLMN architectures and Coverage. [13]

terrestrial mobile and satellite Radio Access Networks (**RAN**s) would be the desired architectures of the future [13] as seen in "Fig. 11". In this scenario, Each RAN have a separate interface to the core network under the same PLMN Global ID. Within this architecture a multi-link aggregation could be applied but not everywhere due to coverage mismatch between both RANs.
The proposed handover scheme could be simulated using different simulation tools like NS3 and Matlab. Author in [25] has listed relevant simulation and emulation platforms used in converged satellite-terrestrial mobile networks.
In case satellite and terrestrial access networks are connected to two different core networks (two different PLMNs), roaming agreements between satellite providers and terrestrial Mobile Network Operators (**MNO**s) should be reached to enable MNOs to extend their coverage into rural low capacity areas with minimum costs.

VI. Conclusion And Future Work

Exploiting satellite network solutions is a great opportunity to achieve 5G key service requirements and truly ubiquitous connectivity. However, integrating satellite into 5G system is facing many challenges including long propagation delays, large Doppler effects, and moving cells. The mentioned challenges are being studied by various standardization bodies and academic researches. The proposed solutions with technologies advancement in different areas make it realistically possible to integrate satellite and terrestrial mobile networks. Throughout the paper we presented different approaches and related works in the literature that can be adopted to overcome the challenges and realize the applicability of satellite and terrestrial mobile network convergence. In addition to that, the paper described a proposed solution for smoothly managing mobility between 5G and satellite network similar to inter frequency handover technique used in terrestrial cellular technology. Therefore, simulating the proposed approach is our main area of focus in future work.

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