International Telecommunication Union

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(07/2019)

Key elements for integration of satellite systems into Next Generation Access Technologies

M Series

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International Telecommunication Union

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REPORT ITU-R M.2460-0

Key elements for integration[1] of satellite systems into Next Generation Access Technologies

(2019)

Scope

Next Generation Access Technologies (NGAT) are envisioned to be highly-advanced, ubiquitous, seamlessly integrated heterogeneous "network of networks" or "system of systems" conceived from the ground up and providing a wide range of services and applications.

In this context, issues such as the geographic coverage, network resilience, flexibility and efficiency will benefit from a variety of networking technologies including other non-terrestrial platforms, such as satellites. This Report provides key elements of satellite networks and use cases envisaged for NGAT.

With integration of satellite systems into NGAT, it is meant that the satellite element of the end-to-end network can be seamlessly managed, (e.g. ensuring end-to-end Quality of Service, Network Slicing, Software Defined Networks (SDN), Network Functions Virtualisation (NFV), Management and Orchestration (MANO), etc.). It is therefore not about "integrating" at the RAN level.

Next generation satellites are currently being designed and put in operation and their integration into NGAT is under study and development by the industry, academia and open standards development organizations. This Report could thus be updated accordingly.

List of acronyms and definitions

CDN	Content delivery network
DTH	Direct-to-home
FOTA	Firmware over the air
Gbit/s	Giga bit per second
GSO	Geostationary-satellite orbit
HD	High definition
HTS	High-throughput satellite
IoT	Internet of things
LEO	Low Earth orbit
M2M	Machine to machine
MEO	Medium Earth orbit
NGAT	Next generation access technologies
NFV	Network functions virtualization
SDN	Software defined networks
SOTA	Software over the air
Tbit/s	Tera bits per second

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[1] The term integration referred to in this Report needs to be understood as being between the distinct elements of wider NGAT land mobile systems.

UE User equipment

UHD Ultra-high definition

1 Introduction

NGAT are expected to be diverse, all-encompassing 'network of networks' and address various usage scenarios (e.g. enhanced Mobile Broadband (eMBB), massive Machine Type Communications (mMTC) and Ultra-reliable and low-latency communications (URLLC)).

Beyond wide coverage capabilities, satellites can also provide communications on the move. The services supported via satellite systems are not limited to just broadband data and voice, but also for others such as machine-type communications, broadcast and other delay tolerant services (in comparison to ultra-reliable and low latency communications (URLLC) requirements). Advancements in satellite capacity and latency capabilities further enhance satellite solution use cases.

The different scenarios have different requirements for coverage, latency and bandwidth. Different technology solutions are expected to play varying roles in addressing the vastly different demands of these scenarios.

Significant advances in data rate and density, latency, virtualization, energy efficiency, security, resilience and other key performance indicators (KPIs) will enable new use cases and business models.

This Report focuses on how satellites are capable of supporting the various scenarios, providing envisaged use cases and key technical elements for careful consideration to enable integration of satellite solutions into NGAT.

2 References

– SANSA, research project under the HORIZON 2020 Framework Programme.

  (Shared Access Terrestrial-Satellite Backhaul Network enabled by Smart Antennas, http://www.h2020.eu/deliverables).

– 3GPP TS 22.261 v.16.7.0 (2019-03) – 'Technical Specification Group Services and System Aspects; Service requirements for the 5G system; Stage 1 (Release 16)'.

– 3GPP TR 22.822 'Technical Specification Group Services and System Aspects; Study on using Satellite Access in 5G' Stage 1 (Release 16).

– 3GPP TR 38.811 v0.3.0 "Study on New Radio (NR) to support non terrestrial networks (Release 15)".

– CEPT ECC Report 280 "Satellite Solutions for 5G" (2018-05).

– 3GPP TR. 38.913 v14.3.0 "Study on Scenarios and Requirements for Next Generation Access Technologies".

– 3GPP TR 38.821 "Study on solutions for NR to support non-terrestrial networks (NTN) (Release 16).

– 3GPP TR 23.737 "Study on architecture aspects for using satellite access in 5G" (Release 16).

– 3GPP TR 28.808 "Study on management and orchestration aspects of integrated satellite in a 5G network" (Release 16).

3 Background and rationale

As stated in Recommendation ITU-R M.2083, § 6.1.2 Relationship between IMT-2020 and other access systems, "[u]sers should be able to access services anywhere, anytime. To achieve this goal interworking will be necessary among various access technologies, which might include a combination of different fixed, terrestrial and satellite networks. Each component should fulfil its own role, but should also be integrated or interoperable with other components to provide ubiquitous seamless coverage".

There are several categories of demand drivers outlined below, which satellite will be able to support various applications, such as:

– Video including multicasting and caching.

– Navigational, weather, traffic and other environmental data.

– Internet of Things (IoT).

– Communication on mobile platforms (e.g. in-flight connectivity for aircraft; connectivity to land vehicles; broadband to ships and trains).

Satellites have the capability to cover a wide area and, in many cases, have high throughput capacity which allows the following:

– Scalability: by leveraging multicast capabilities across a wide area with simultaneous local caching in the cloud as close as possible to the end user, significant "statistical multiplexing benefits" can be gained, leading to a more efficient use of overall bandwidth and a more reliable service.

– Rapid deployment of connectivity: satellite ground stations can be rapidly deployed to connect any place within their footprint, allowing connection of cities, villages, businesses and homes with a predictable quality of service. Moreover, satellite networks are resilient to physical attacks and natural disasters – a property that provides a solution for secure communications.

Therefore, in some cases, satellites will be able to help facilitate the development of NGAT. A number of satellite-specific key elements and use cases are considered in § 4, broader supporting satellite technology in § 5 below and key elements for consideration in § 6.

4 Satellite use cases

Four main use cases can be identified for satellite-based solutions into NGAT: Trunking and Head-end Feed, Backhauling and Multicasting Tower Feed, Communications on the Move and Hybrid Multiplay.

These cases are characterised by their scale: from a few hundred or thousand sites for the Trunking and Head-end Feed use case to potentially millions in the case of Communications on the Move and Hybrid Multiplay use cases, as well as the fixed or mobility abilities of the platform connected via satellite.

TABLE 1

Example of satellite-based use cases

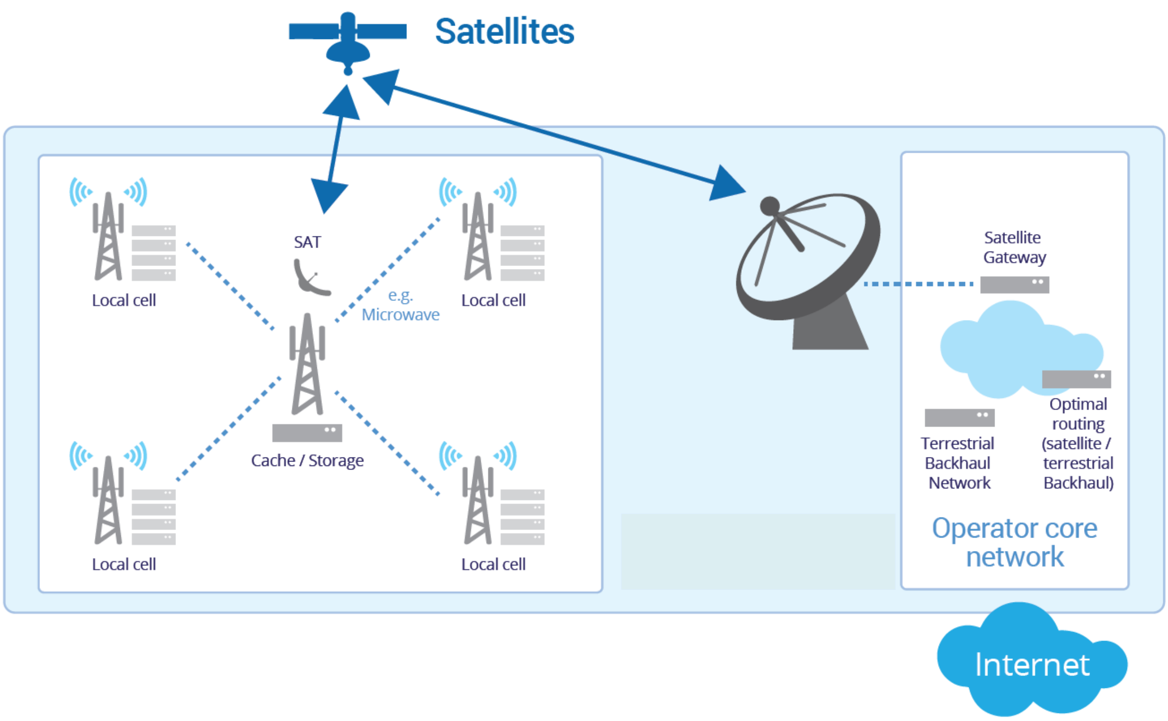
Use cases	Examples	Number of sites
Trunking and head-end feed	Service to remote areas; special events	Limited to unserved areas in a carrier's network
Backhauling and Multicasting tower feed	Surge capacity to overloaded cells, plus content delivery (e.g. video) to local caches; efficient broadcast service to end users	Thousands
Communications on move	In Flight Connectivity for Aircraft; connectivity directly to land vehicles; broadband to ships and trains	Potentially millions
Hybrid multiplay	Video and broadband connectivity directly to home or multi-tenant building with NGAT distribution in building	Potentially millions

4.1 Trunking and Head-end Feed

In the Trunking and Head-End Feed use case, satellites provide high speed direct connectivity option to remote and hard to reach connections.

FIGURE 1

Representative diagram of the Trunking and Head-end Feed use case



A high throughput satellite link from geostationary and/or non-geostationary satellites has the capability to complement existing terrestrial connectivity to enable high speed trunking of video, IoT and other data to a central site, with further terrestrial distribution to local cell sites (e.g. current and future cellular networks), for instance neighbouring villages, as shown in Fig. 1.

In this category, only broadband (i.e. unicast, VSAT terminals) communications are supported and the satellite links are bidirectional. There is no use of multicasting to populate edge caches, which corresponds to a major difference with respect to the rest of the use cases presented in §§ 4.2, 4.3 and 4.4.

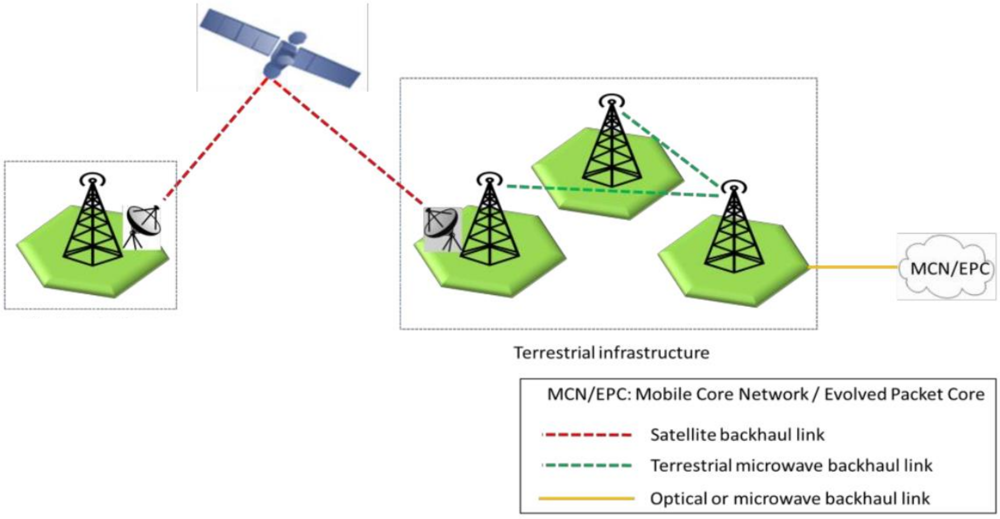
Scenarios for the Trunking and Head-end Feed Use Case include[2]:

– broadband connectivity to remote areas: For example, coverage on lakes, islands, mountains, rural areas, isolated areas or other areas that are easily covered by satellites;
– satellite-based connectivity to support Wi-Fi services to remote communities with limited or no broadband internet service. The equipment is installed at a central location, usually a local business and, in some cases, extended to nearby areas through a point-to-multipoint Wi-Fi (P-MP) connection;
– emergency response in wide scale natural disasters, other specific public emergency situations and other unforeseen events where satellites are the only option;
– broadband connectivity for network Head-End;
– secondary/backup connection (limited in capability) in the event of the primary connection failure;
– remote cell connectivity as illustrated in Fig. 2: The following use cases can be considered as a part of the remote cell connectivity scenario:
  • Stand-alone cells;
  • Reoccurring events;
  • Rarely repeated events (concerts, sport events).

[2] Note that if there is multicast need/opportunity and if there is existing terrestrial connectivity available, these provided use case scenarios may fall under the Backhauling and Multicasting Tower Feed category as well.

FIGURE 2

Example of remote or temporary cell

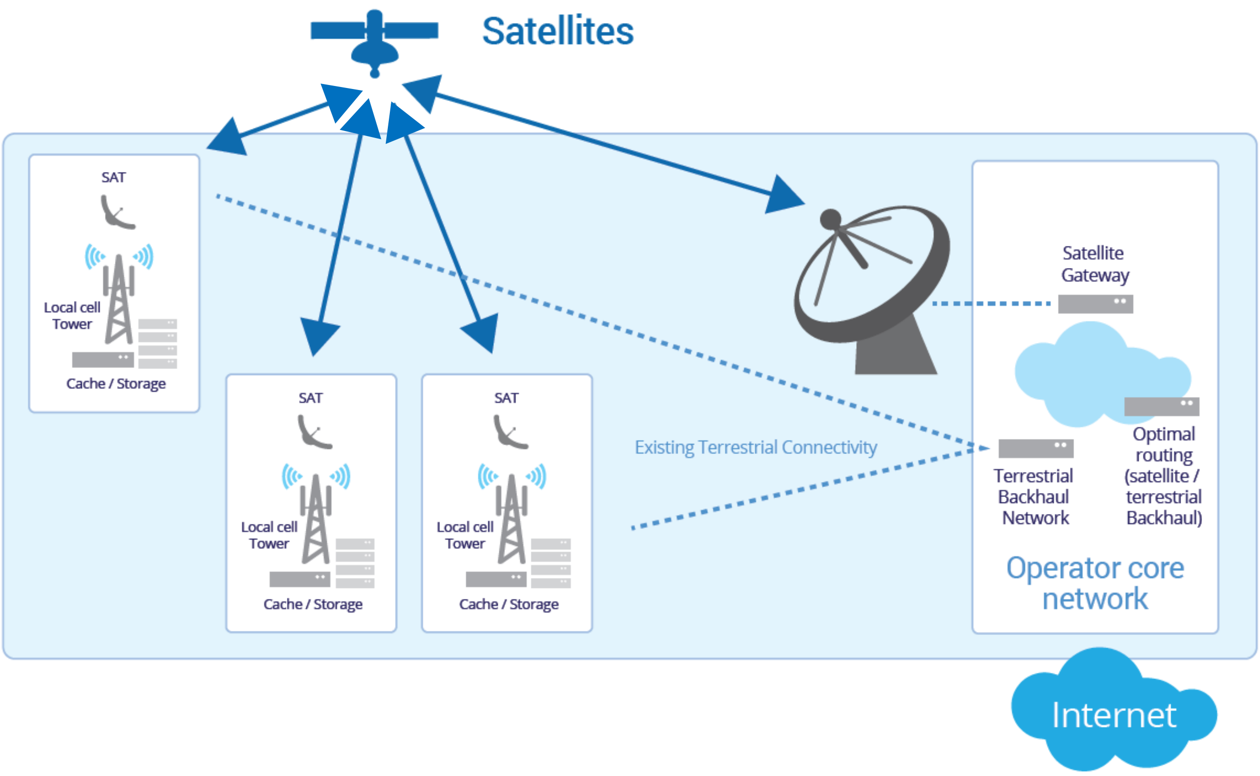


4.2 Backhauling and Multicasting Tower Feed

In the Backhauling and Multicasting Tower Feed use case, satellites are one of the solutions for providing high speed multicast connectivity to wireless towers, access points and the cloud.

FIGURE 3

Representative diagram of the Backhauling and Multicasting Tower Feed use case



A high throughput, multicast-enabled, satellite link from geostationary and/or non-geostationary satellites, direct to the cell towers complements existing terrestrial connectivity to enable backhaul connectivity to individual cells with the ability to multicast the same content (e.g. video, HD/UHD TV, as well as non-video data) across a large coverage area as well as efficient backhauling of aggregated IoT traffic from multiple sites.

In cases of low latency applications where content is cached at the edge of the network, that content may be delivered by satellites in some cases. The use of multicasting to populate edge caches is a major difference of this use case with respect to the one presented in § 4.1.

Scenarios for the Backhauling and Multicasting Tower Feed use case include:

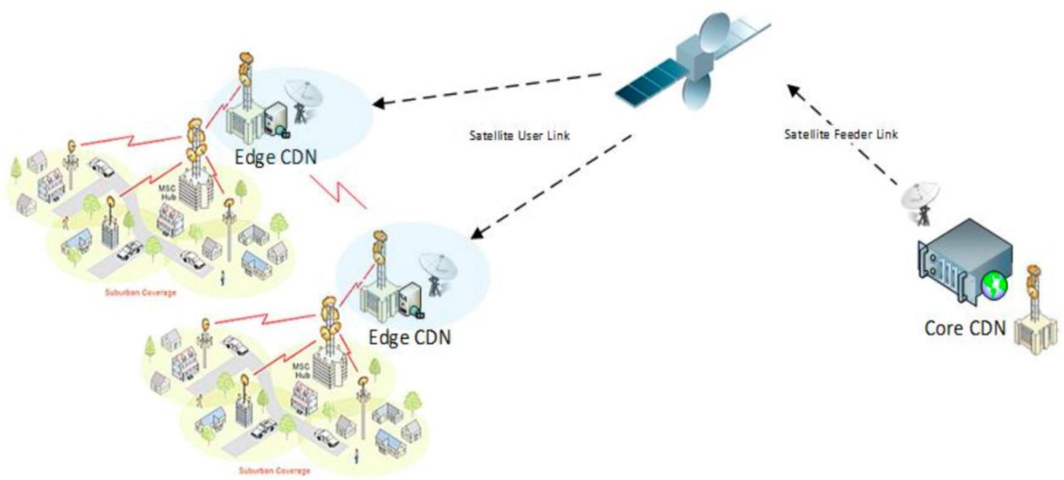
– broadcast services to end users, etc. (e.g. video, software download), support of low bit-rate broadcast service (e.g. for emergency messages and synchronization of remote sensors and actuators);

– providing efficient multicast/broadcast delivery to network edges for content such as live broadcasts, ad-hoc broadcast/multicast streams, group communications, Mobile Edge Computing / Virtual Network Function (MEC VNF) update distribution.

Satellite can be an effective means to support edge compute functions such as caching and content processing capabilities. Depending on the deployment scenario, content is delivered to the cache either by satellite via gateway or through terrestrial connection to the Evolved Packet Core (EPC) or Content Delivery Network (CDN) edge network. An example when all the content is sent to the edge CDN by feeding only through satellite is demonstrated in Fig. 4.

FIGURE 4

CDN Operation via Satellite Only

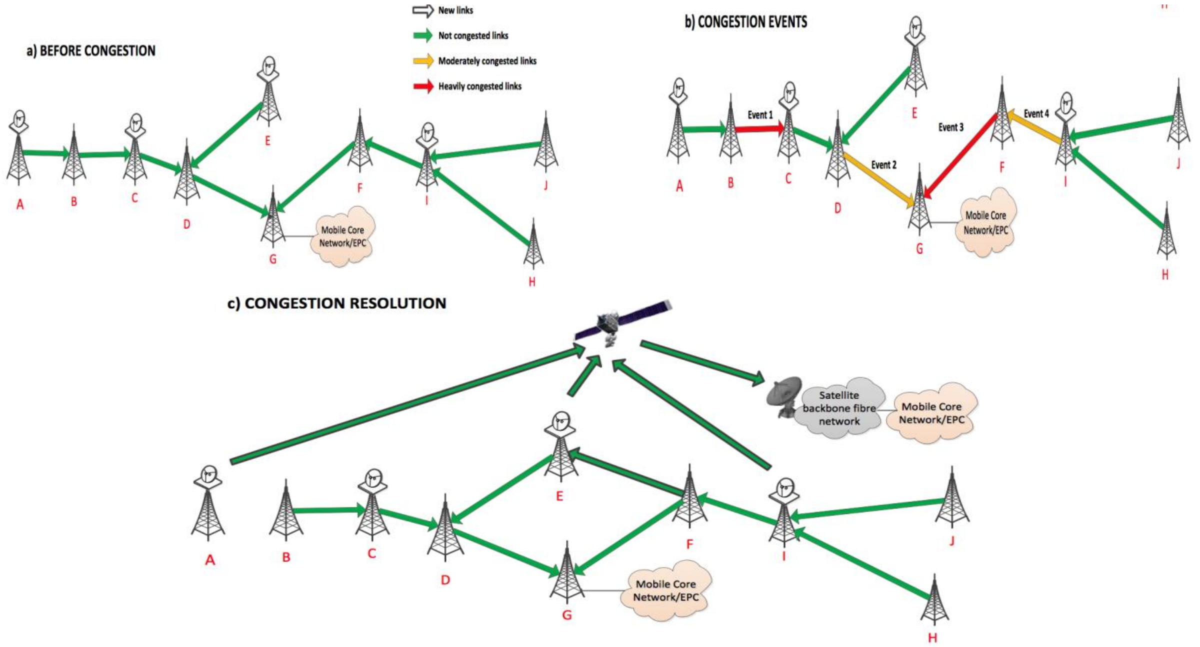


Satellite connectivity, with the help of hybrid network management, can add flexibility to backhauling networks by either providing an alternative route, through satellite, or through an alternative terrestrial link when another node is available. Future developments of smart antennas with steerable beams may further assist in this use case.

Figure 5 provides an illustration of a deployment scenario demonstrating how the satellite solution can resolve congestion problem, in case of congestion events.

FIGURE 5

Deployment scenario demonstrating how satellite solution can resolve congestion problem[3]



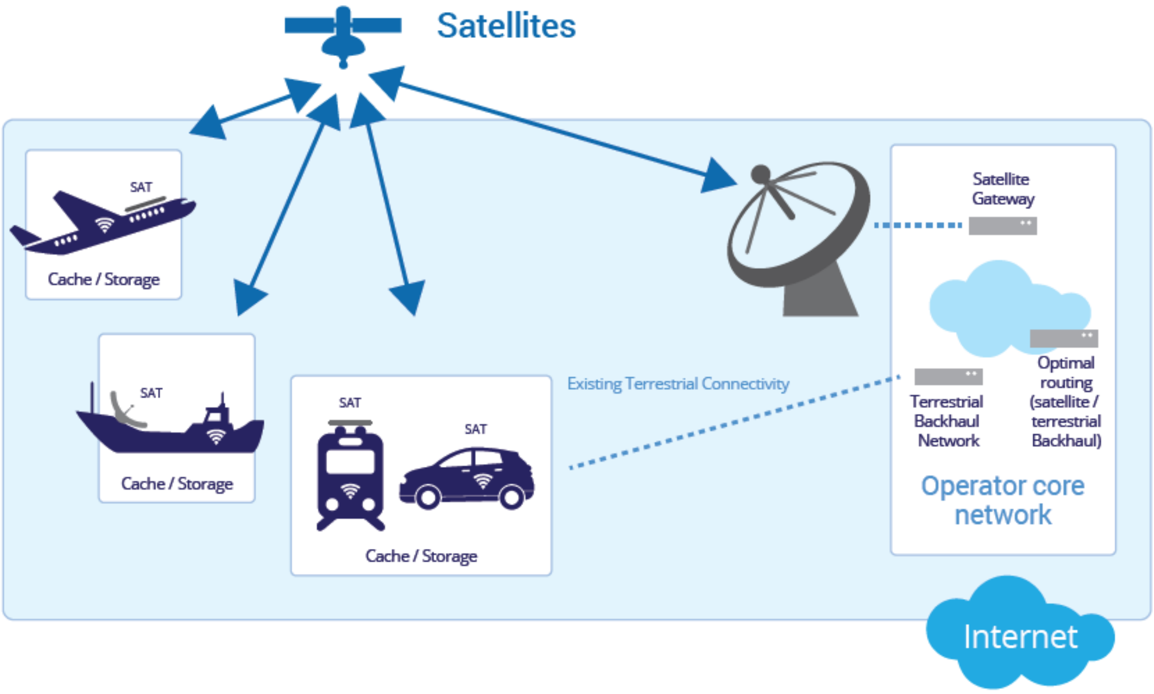
4.3 Communications on the Move

In the Communications on the Move use case, satellites provide a direct and/or complementary connection for users on the move such as on planes, trains, vehicles and ships.

3 This use case was developed in the course of the SANSA project and reported in the deliverable D2.3 "Definition of reference scenarios, overall system architectures, research challenges and requirements and Key Performance Indicators".

FIGURE 6

Representative diagram of the Communications on the Move use case



A high throughput, multicast-enabled, satellite link from geostationary and/or non-geostationary satellites, provides connectivity to individual planes, vehicles, trains and vessels (including cruise ships and other passenger vessels), with the ability to stream unicast on demand content (e.g. Over-the-Top IPTV) or multicast the same content (e.g. video, HD / UHD TV, as well as other non-video data such as FOTA/SOTA) across a large coverage (e.g. for local storage and consumption), as shown in Fig. 6. The same capability also allows for the efficient direct connectivity to end user devices or sensors and aggregated IoT traffic from these moving platforms. This use could be a solution for complementing existing terrestrial connectivity where available.

Scenarios for Communications on the Move use case include:

– broadband connectivity to moving platforms, such as airplanes or land or sea vessels;

– connectivity complementing or interworking with terrestrial networks: Broadband and content multicast connectivity to platforms on the move in conjunction with a terrestrial based connectivity link to base stations or relay on board moving platforms such as high speed trains/buses and other road vehicles to ensure service reliability, and coverage of rural areas, and big events in ad-hoc built-up facilities;

– connectivity for remotely deployed battery activated M2M/IoT sensors, or handset devices with messaging/voice capabilities via satellite (e.g. fleet management, asset tracking, livestock management, farms, substations, gas pipelines, digital signage, remote road alerts, emergency calls, mission critical/public safety communications, maritime research, oceanographic observation, tsunami observation, meteorological observation, etc.);

– IoT devices on containers (e.g. for tracking and tracing) connected via a relay UE on a transport vehicle such as a ship, train or truck;

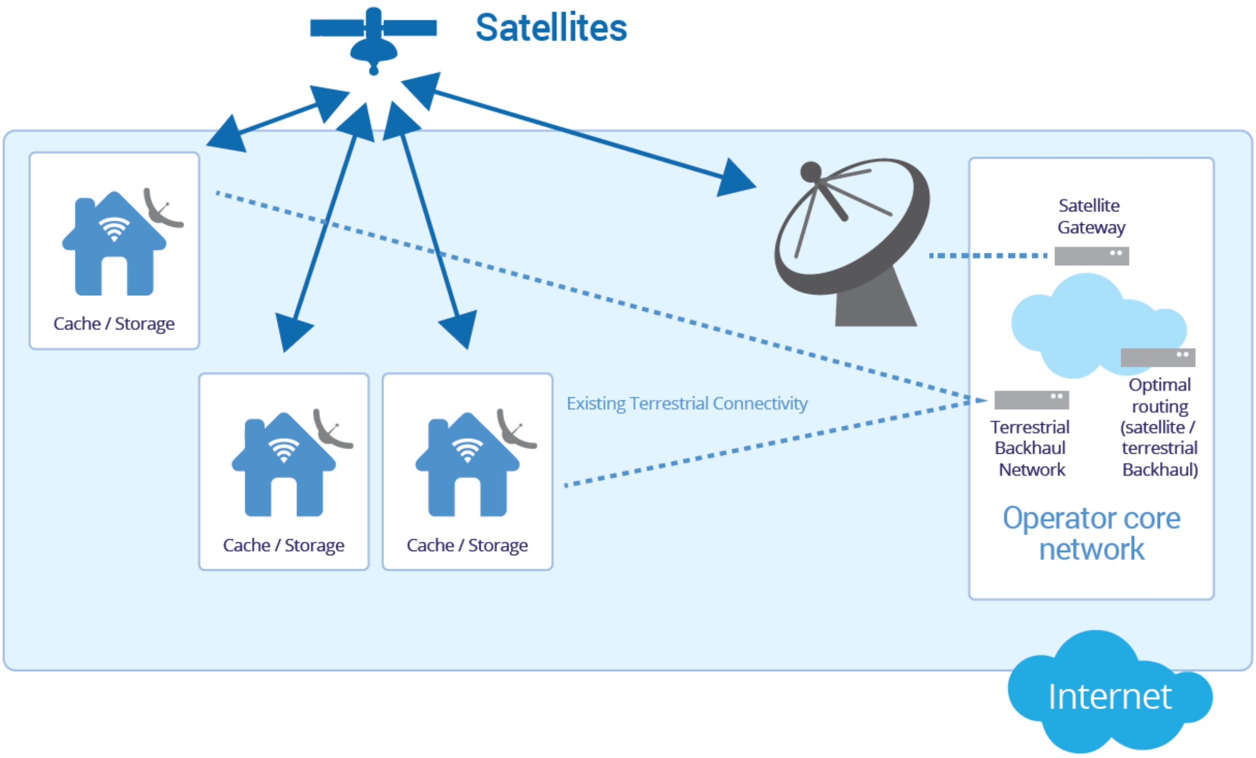
– for connected cars, enabling Over the Air Firmware and Software (FOTA/SOTA) services, information updates such as map information including points of interest (POI), real-time traffic and Parking availability (Telematics) as well as Infotainment, increased coverage and reliability for e-Call services, vehicle tracking and remote diagnostics.

4.4 Hybrid Multiplay

In the Hybrid Multiplay use case, satellites are a solution for delivering content complementing or interworking with terrestrial broadband to individual homes and offices, as well as providing direct broadband connectivity in some case with the ability to multicast the same content (video, HD/UHD TV, as well as other non-video data) across a large coverage area (e.g. for local storage and consumption). The same capability also allows for an efficient connectivity for aggregated IoT data. In-home distribution via Wi-Fi or very small cell ("nano-cell") is shown in Fig. 7.

FIGURE 7

Representative diagram of the Hybrid Multiplay use case



A high throughput, multicast-enabled, satellite link from geostationary and/or non-geostationary satellites has the capability to complement, or interwork with existing terrestrial connectivity, as well as to provide direct broadband connectivity for in-home or in-office distribution via Wi-Fi or femto and nano-cells, and Direct-To-Home (DTH) satellite TV, integrated within the home or office IP network. The satellite user links are either bidirectional and/or unidirectional since, depending on the case, broadband (i.e. unicast, thus VSAT and electronically steered terminal technology) and/or broadcast/multicast (thus, receive only terminals) communications are supported by this category.

Scenarios for the Hybrid Multiplay use case include:

– Connectivity complementing, or interworking with, terrestrial networks as well as direct connectivity:
  - Broadband connectivity to home/office small cell in underserved areas in combination with terrestrial wireless or wireline.

Satellite connectivity with the help of hybrid network management can add flexibility by either providing an alternative route, through satellite, or through an alternative terrestrial link when another node is available. Future developments of smart antennas with steerable beams may further assist in this use case.

5 Innovation in the Satellite Sector

5.1 Satellite Technology

Both geostationary satellite orbit (GSO) networks and non-geostationary satellite systems (non-GSO) provide unique benefits to NGAT.

GSO satellites provide efficient coverage for entire continents and countries from a fixed point with respect to the earth. High Throughput satellites (HTS) through highly focused beams combined with frequency reuse are being designed and built to provide a throughput from hundreds of Gbit/s up to more than 1 Tbit/s from each orbital location.

The geostationary position at around 36 000 km from the earth's surface results in a propagation delay of approximately 250 ms (500 ms for the round trip delay), which needs to be taken into consideration for the end-to-end latency sensitive traffic assessment, while recognizing not all traffic is latency-sensitive. The effective latency can be further reduced through the use of hybrid networks where less latency-sensitive traffic is routed through high bandwidth satellite connections, reserving those terrestrial connections with lower capacity for latency-sensitive traffic.

Non-GSO satellite systems may generally operate at lower orbits than geostationary satellites; this has a beneficial impact on latency for some applications which are latency-sensitive. As an example, Medium Earth Orbit (MEO) satellite systems operate at a quarter of the distance to the Earth as compared to geostationary satellites, and the propagation delay is therefore below 75 ms (150 ms for the round trip delay). As non-geo satellites are orbiting around the earth, continuous coverage requires the deployment of a satellite constellation. Non-geostationary constellations provide hundreds of Gbit/s and even Tbit/s of throughput across the globe, with aggregate supply scalable with the number of satellites per constellation plane.

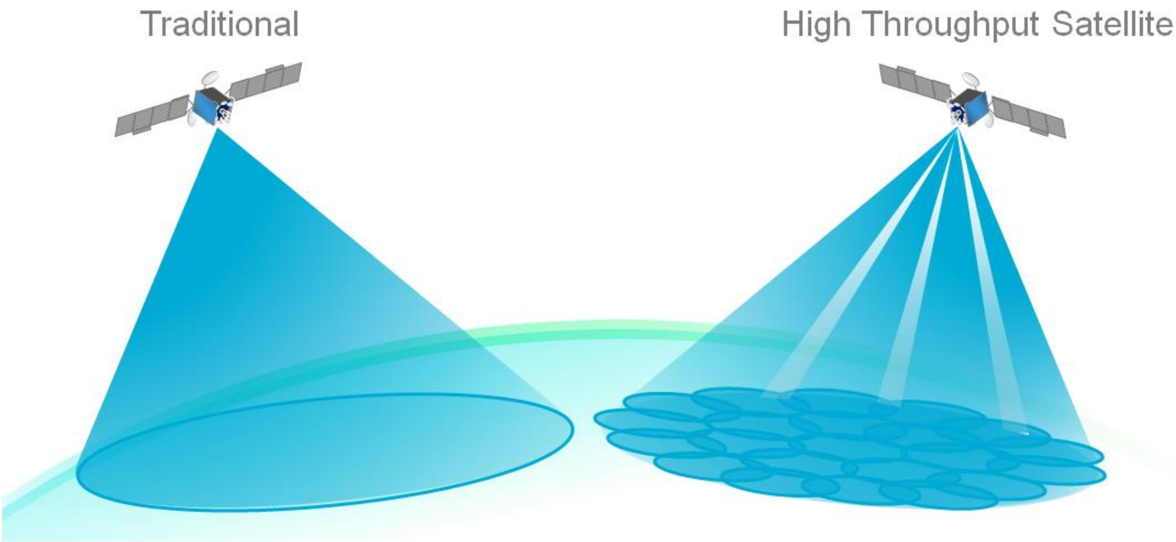
5.2 High Throughput Satellites (HTS) driving Innovation

GSO, MEO and LEO High Throughput Satellite (HTS) systems are improving satellite throughput, capacity and cost, as well as providing flexible, global and high performance services compared to traditional satellite services.

HTS systems utilise concentrated spot beams, wideband payloads, increased frequency re-use and higher frequency bands to significantly increase capacity and speeds over wide areas as demonstrated in Fig. 8. HTS networks are operating on a global basis and can provide broadband service to end-users with speeds in excess of 100 Mbit/s. These systems can support a wide variety of applications, including broadcast and multicast distribution of content, and aid towards bridging the digital divide by offering high speed, high capacity, anywhere, anytime services.

FIGURE 8

Difference between Traditional Satellite Beam and HTS Spot Beams



Key technologies will include improved interference mitigation, dynamic beam forming, flexible beam hopping, on-board processing and even greater frequency reuse.

At the same time there is a resurgence in MEO and LEO HTS constellation approaches that will offer true global coverage, network wide uniform service delivery and substantially reduced latency. A variety of HTS constellation approaches offer connectivity ranging from fibre replacement services, private wide area networks and consumer broadband.

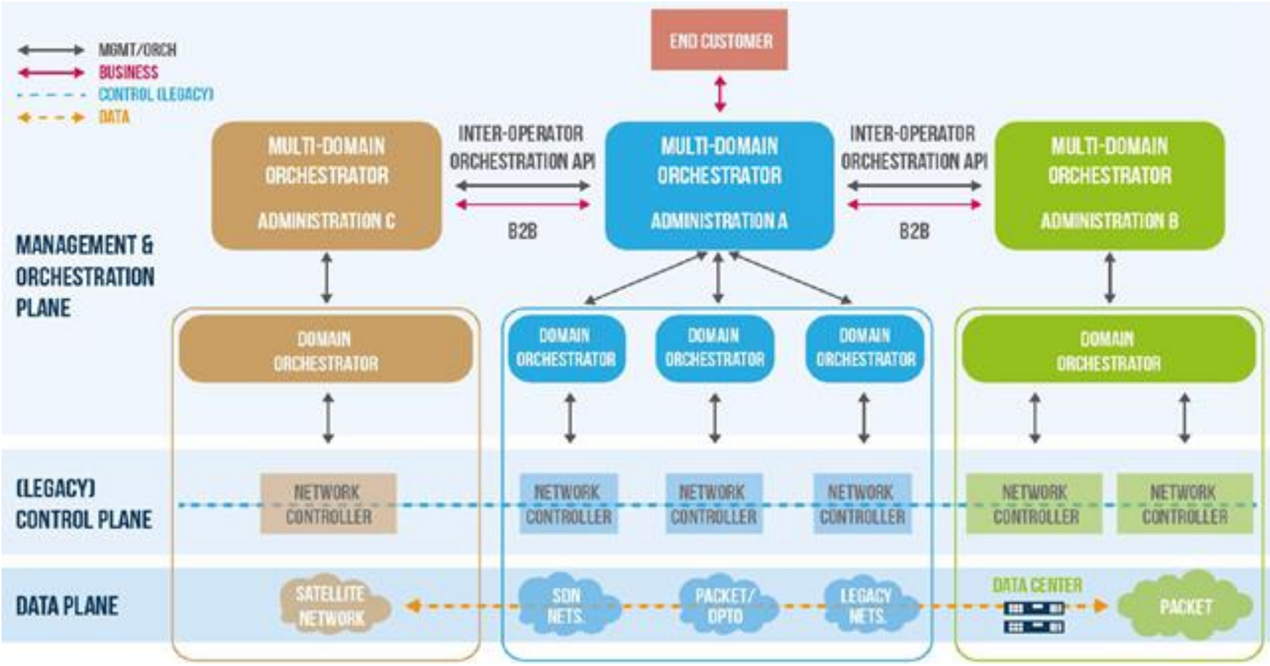
All classes of HTS systems are expected to dramatically increase total throughput, allowing further significant reductions in bandwidth costs.

5.3 Advanced satellite ground segment technology

Satellite system ground segment is adopting technology developments of the NGAT in areas such as service delivery, network-slicing, orchestration, mobile edge computing, security, interoperability and resource virtualisation in order to transparently support end-to-end service delivery to various verticals. This involves the adoption of satellite modems, network platforms and management systems which will support hybrid connectivity services, whilst benefiting from the efficient radio architectures, resource sharing and the multicast capabilities of current systems. Figure 9 shows an example of how services on end-to-end networks, traversing different operators can be organized.

FIGURE 9

Satellite Service Delivery orchestrated as part of a multi-network NGAT[4]



5.4 Phased array antenna technology

As satellite communication terminals continue to become cheaper, smaller and more power efficient, a wide variety of terminals are being made available via the emergence of a new wave of flat panel antenna technology. To enable more widespread adoption of satellite broadband for mobile users, developments in new mobile satellite communications terminals using advanced materials to offer cost effective, low-profile phased array technologies are being introduced. These 'phased array' antennas have no mechanical components and rely on software and electronics for steering, making them ideal for mobile platforms like cars, boats, planes and more.

Phased array antennas rely on microprocessor technology and software algorithms for combining signals received by numerous element antennas. In most cases, each antenna “panel” is populated with a collection of independent “patch” antennas and corresponding beam forming microchips. It is equivalent to one big antenna made up of multiple smaller antennas that receive signals that must be processed and combined. An example is the new reconfigurable antenna technology, known as Metamaterials Surface Antenna Technology (MSA-T), shown in Fig. 10.

This offers the electronic beam-steering performance of a typical phased array antenna, with much lower power consumption and a dramatic cost reduction compared to mechanical products and many of the size, weight and power challenges associated with the existing techniques are alleviated.

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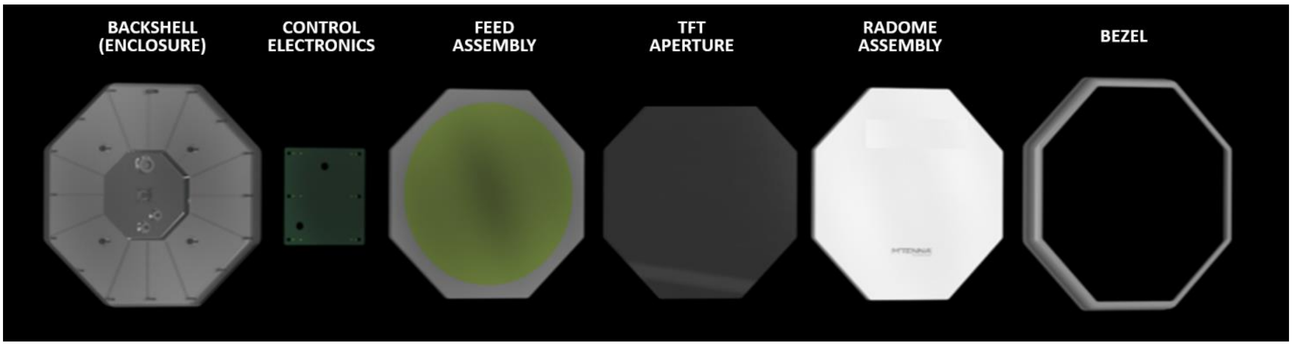
[4] Source: 5G-PPP White Paper: Innovations for new Business Opportunities.

FIGURE 10

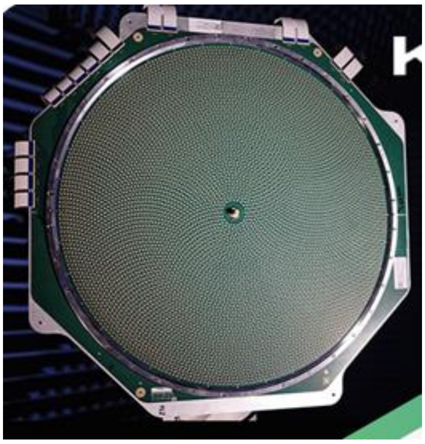
Antenna array and feed network antenna



These new small antenna solutions combined with efficient energy generation and storage systems will allow satellite communications to better support cost-effective service delivery to off-grid locations in remote regions and the developing world.

FIGURE 11

Typical flat panel satellite antenna solutions



5.5 Spectrum usage – high level overview

Satellite systems use a number of different frequency bands, or portions thereof, to address a variety of usage/markets. Many of these bands have co-primary allocations with other radiocommunication services. A summary of the example applications and satellite usage in various frequency ranges is given in Table 2 (note that the frequency ranges in the table are not necessarily associated with each Usage/Market).

TABLE 2

Example applications and satellite usage by frequency range

Band	Usage / Market	Description Note: Descriptions include traditional satellite example applications, as well as example applications with relevance to NGAT.
L	Mobile satellite services	These frequencies are used for mobile data and voice communications to small user terminals. Global satellite phones, Machine-to-Machine/IoT, asset tracking, as well as aeronautical and maritime safety communications are examples of satellite applications in this band.
S	Mobile satellite services	These frequencies are used for mobile data and voice communications to small user terminals. Global satellite phones, Machine-to-Machine/IoT, asset tracking as well as aeronautical and maritime safety communications are examples of satellite applications in this band.
C	Cable head-end broadcasting / Video Trucking / VSAT	This band is heavily used for video distribution, VSATs and data communications over a wide area. This band is primarily used by satellites for hemispheric or continental coverage. While used mainly for service to fixed locations, it is increasingly used for data communications for in-motion services.
Ku	Direct to home broadcasting / Broadband / VSAT / In-motion services / Mobile Backhaul	Used for data communications to fixed and in-motion services. Global networks serving maritime, aviation and land based services, as well as national and regional VSAT networks, Satellite News Gathering and video distribution. Recently used for High Throughput Satellite services for high speed capacity connections.
Ka	Broadband applications / VSAT / In-motion services / Mobile Backhaul / Feeder links	Used to provide broadband communications. A number of national, regional and global networks have been put in place that can provide high-speed broadband connections to residential, commercial and mobile (ships, trains, aircraft) customers. Used for High Throughput Satellite services which smaller CPEs providing reduced cost and higher data rates.
Q	Broadband applications / VSAT / In-motion services / Mobile Backhaul / Feeder links	Future High Throughput Satellites used for additional feeder-link services. HTS will also be used to provide high-speed broadband communications to residential, commercial and mobile customers.
V	Broadband applications / VSAT / In-motion services / Mobile Backhaul / Feeder links	Future High Throughput Satellites used for additional feeder-link services. HTS will also be used to provide high-speed broadband communications to residential, commercial and mobile customers.

6 Key elements for consideration

This section addresses the key technical requirements that need to be considered in order to be able to provide efficient satellite solutions for the Next Generation Access Technologies.

6.1 Multicast support

There is a need to ensure that multicasting is defined, feasible and implemented across the whole network (cloud, core, access).

6.2 Unicast support

There is a need to ensure that unicast is defined, feasible and implemented across the whole network (cloud, core, access).

In comparison with terrestrial networks, satellite networks have a large coverage, typically corresponding to tens of thousands of cells of a terrestrial network. The satellite can unicast / multicast / broadcast content over a large area. A satellite network can also contribute to off-loading traffic from terrestrial networks during the busy hours by multicasting or broadcasting non time sensitive data in non-busy hours. A satellite network can also contribute when communications on the move are required.

6.3 Intelligent routing support

There is a need to ensure that traffic always follows the optimal path through the network, with potential differentiation across user and control planes, ‘fat’ and ‘thin’ pipes, different use cases (e.g. low bandwidth M2M vs high bandwidth video), different types of content (e.g. messages, images, video) and different latency requirements (e.g. high latency M2M vs low latency web browsing or store and forward IoT data). Other important aspect to be considered by the new to-be-developed routing algorithms includes link and energy costs or regional restrictions.

6.4 Dynamic cache management and adaptive streaming support

There is a need to optimally store and stream content, regularly refreshed as appropriate, as close as possible to the end user, in order to enable the most scalable and cost-effective solution.

6.5 Latency

Satellite networks are designed to ensure that protocols allow flexibility such that the application layer identifies the latency requirement envisaged and the overall infrastructure path end-to-end, and then chooses the appropriate physical layer path optimizing the overall network of networks performance.

This is critical to ensure that communication paths with inherently longer propagation delays (e.g. geostationary satellite links) can be accommodated where that makes sense (e.g. backhaul in sparsely populated areas, content and use cases that do not require “very low latency”).

For NGAT applications that have low latency requirements (e.g. tactile Internet, virtual reality), satellites can play a role in providing connectivity to complement or interwork with terrestrial networks to deliver such applications. Latency is the result of the entire end-to-end connection to the destination user or server. It is likely that services requiring a very low delay time will use some content served from a physical position close to the user’s device, possibly at the base of several cells, including the many small cells that are predicted to be fundamental to network densification.

Efficient, unicast and multicast distribution of commonly accessed content to data caches located at each satellite modem, cell and small cell could be deployed in NGAT networks to support applications requiring low latency.

6.6 Persistent Quality of Service

This is defined as the ability, in conjunction with local cache management, to adapt to the user's connectivity parameters.

6.7 NFV / SDN compatibility

Satellite network elements should be compatible with standards for Network Functions Virtualization and Software Defined Networks.

6.8 Business model flexibility

The successful deployment of NGAT could benefit from new partnerships between horizontal and vertical sectors. Architecture and standards should allow for a wide variety of business models and partnerships.

6.9 Content / Asset Rights Management and Security

This is defined as the ability to secure property rights of content and other assets and to maintain end to end network security, while ensuring that multicast and caching capabilities are preserved.

7 Summary

Due to capabilities including wide coverage, rapid deployment, inherent multicast, and high throughput, satellite systems integrated with NGAT are expected to provide scalable and efficient network solutions globally. Both geostationary and non-geostationary satellite systems have a role to play in this context.

This Report provides key elements of satellite networks and use cases envisaged which deserve consideration to enable successful integration of satellite solutions into NGAT.