WHAT YOU NEED TO KNOW ABOUT INTEGRATING 5G AND SATELLITE

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Read On: What’s Inside

The new cellular standard 5G provides blazing-fast mobile broadband speeds, exponentially higher efficiencies, massive scalability and significantly lower cost for mobile and fixed networks, along with ultra-low latency to enable new applications like massive machine-to-machine (M2M) communications and the Internet of things (IoT).

5G promises to offer a unified network infrastructure where all access technologies (wired, wireless, terrestrial and satellite) work in sync. This is also called the Network of Networks, a fully interoperable end-to-end network. 5G opens up new opportunities for satellite communications (satcoms) to integrate seamlessly with the mainstream telecom network. For the first time in the definition of cellular standards, satellite access is being included from the start.

At Isotropic™, it is our mandate to bring the Network of Networks to life. Isotropic demonstrates its commitment to advancing 5G deployment in the industry by playing an active role in validating new 5G satellite applications and by creating new management tools that can power 5G systems. We have developed Datadragon™, an intelligent bandwidth management solution designed to help our clients optimize fully converged networks, including future 5G solutions.

This white paper shares insights from Isotropic efforts that we hope can help mobile network operators (MNOs) and our clients better prepare for tomorrow’s challenges today.

Looking at 5G and satellite applications, we discuss 5G rollout and networking challenges for MNOs that Isotropic’s hybrid satellite-terrestrial networking can help address.
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Introduction

Created by the 3GPP standards-setting body as the fifth-generation technology for mobile and cellular networks and operators, 5G is a new network architecture for mobile (Wi-Fi, metro and small cells) as well as multiple access technologies such as satellite. Research firm Strategy Analytics forecasts that sales of 5G smartphones will grow from less than 1% of sales today to exceed 1 billion devices worldwide by 2025 as carriers continue to build out 5G networks. 5G is expected to generate massive growth in data traffic as millions of mobile subscribers continue to convert from current 3G and 4G/LTE to next-generation 5G in the coming years.

5G brings exponential improvements in speed, latency, capacity, power consumption and the number of devices supported by cellular networks, including the following:

- User download speeds up to 100 Mbps, uploads at 50 Mbps\(^1\)
- More remote devices—5G will have the ability to support millions of devices in a square kilometer, including user equipment (UE) moving as fast as 500 km/hr
- New lower-latency applications

MARKETS AND SERVICES

5G is expected to enable many new markets and services. The International Telecommunications Union (ITU-R) has defined three main use areas for 5G:\(^2\):

- **Enhanced Mobile Broadband (eMBB):** eMBB use cases evolve beyond 4G LTE mobile broadband services and offer order-of-magnitude faster connections, higher throughput and more capacity. eMBB also specifies lower latency compared to 4G LTE. eMBB enables rich media applications such as mobile augmented reality (AR) and virtual reality (VR) as well as 4K and 360-degree video streaming.
- **Ultra-Reliable Low Latency Communications (URLCC):** This use area is targeted toward mission-critical applications that require uninterrupted and robust data exchange. Examples include connected, robot-enabled remote surgery and self-driving vehicles.
- **mMTC (Massive Machine Type Communications):** mMTC is a type of highly scalable narrowband, wider area cellular data access for sensing, metering and monitoring use cases that connect to many low-power, low-cost and high-battery lifetime devices. Also known as large-scale IoT networks, potential applications include smart cities and smart utilities.

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\(^1\) Source: “What the Satellite Industry Needs to Know About 5GSG,” SpaceNews, 8/27/2018

\(^2\) https://www.electronicdesign.com/embedded-revolution/5g5G-it-s-not-here-yet-closer-you-think
5G TECHNOLOGIES

5G combines technologies:
- EPC (Evolved Packet Core)/5G core from cellular technology
- NFV (Network Function Virtualization) and SDN (Software Defined Network) networking
- Virtualization and Cloud technology from the IT world

5G expands cellular frequency use into three main frequency ranges. 5G millimeter wave frequencies increase available bandwidth and spectrum efficiency compared with 4G but reduce individual cell coverage range, therefore requiring more cells per square mile of service.

The 5G core uses software-based network functions to virtualize and automate service delivery. 5G networks can be shrunk and built at lower cost by using virtualization so that components of the network can be run as virtual machines (VMs). Moving the control plane of the 5G core to a Cloud provider reduces cost.¹

VIRTUAL NETWORKS: NETWORK SLICING

With the network slicing function (NSF) in 5G’s architecture, dedicated logical networks can be created dynamically over a single physical network infrastructure. Network slicing with 5G performs transparent insertion of different network slices over the Network of Networks’ combined resources. Resource allocation can be centrally managed. Network slices can be configured to turn up services that meet a variety of market needs:
- Consumer—broadband mobility/cell
- Enterprise—mobile services
- IoT—utilities, vehicles, agriculture, sensors, etc.
- Mobile virtual network operator (MVNO)—virtual MVNO networks

Depending on the service details, satellite network capacity can be part of the physical infrastructure resources in a network slice.

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<thead>
<tr>
<th>5G FREQUENCY RANGE</th>
<th>KEY FEATURES</th>
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<tbody>
<tr>
<td>Low band (below 1 GHz)</td>
<td>Can travel long distances but at slower speeds</td>
</tr>
<tr>
<td>Mid band (1-6GHz)</td>
<td>Can travel long distances at high speeds</td>
</tr>
<tr>
<td>High band (above 24GHz)</td>
<td>Commonly referred to as millimeter wave — travels shorter distances but at very high speeds.</td>
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Where Do 5G and Satellite Make Sense?

5G’s future impact on satellite has been called a revolution. Experts say it will dramatically affect how satellite networks integrate into the terrestrial network. Unlike past standards, where VSAT equipment had to catch up and integrate with mobile/cellular network standards, 5G is being standardized to enable full interoperability with satellite from the outset.

The 3GPP is working to integrate current and future satellite constellation types into the 5G standard architecture so that a seamless service and traffic flow can be created for many new types of services.

3GPP members and the industry have recognized the key advantages that satellite communications can bring to mobile networks. They include the following:

- Wide area coverage/ubiquity—the ability to reach anywhere on the globe wirelessly beyond the reach of terrestrial infrastructure
- Mobility—anywhere connections to moving platforms (e.g., aircraft, trains, ships, vehicles, unmanned aerial vehicles)
- One to many/multicast—efficient simultaneous, wide-area data broadcast to dispersed sites for live transmission or local/edge caching
Isotropic shares the industry view that satellite networks can help service providers maximize 5G in several ways:

- **5G Fixed Cellular Backhaul:** Satellites can affordably extend connectivity to 5G base stations (gNB) and even user devices beyond the reach of terrestrial networks — for example, into remote, rural, low-density locations.

- **Moving Platforms/Roaming:** Satellites can provide broadband connectivity to aircraft, vessels, rail and vehicles outside of cell range and support cellular roaming services for subscribers or devices on mobile platforms.

- **Media/Multicasting:** Satellites can efficiently multicast livestream broadband media and cacheable apps and content to distributed 5G edge nodes. As a result, they can reduce connectivity requirements for backhaul connections to base stations and improve end-user service quality.

- **Redundancy/Backup:** Satellite networks can also provide backup capacity and mobile/transportable 5G cells for emergencies and disaster recovery connectivity when terrestrial networks are down—for example, due to cable cuts or natural disasters.

- **IoT:** For low bit rate IoT networks with latency-insensitive applications, VSAT satellite terminals can efficiently concentrate local traffic in remote locations or on moving platforms for connectivity to the core network (CN).

- **Network Efficiency Gains:** Offloading low-priority traffic or multicastable content from backhaul networks (enterprise or cell) can help preserve precious spectrum on the main network or provide overflow capacity for peak periods.

Satellite networks efficiently multicast livestreams and big data to distributed edge servers on a 5G network. This can free up precious spectrum between cell nodes and/or backhaul capacity so that other, more latency-sensitive types of traffic can run between the gNB and CN over terrestrial connectivity.

In addition to reducing backhaul load, by providing a cache at the base station close to the edge, satellite can reduce user latency compared with pulling content from the Cloud. As 4K video streaming services—and smartphones with 4K screens—become more widespread, this caching capability along with multicast could become important to delivering improved user Quality of Experience (QoE).

5G networks that use millimeter wave frequencies will require more base stations per square kilometer of coverage compared with LTE and 3G. The higher base station count increases the number of terrestrial backhaul points that will need to be added to the network. Satellite multicast networks are extremely bandwidth efficient for multipoint networks, adding zero incremental bandwidth cost as the number of sites scales up.
Seamless End-to-End Satellite and 5G Terrestrial Services

ISOTROPIC NETWORKS AND 5G
Isotropic is testing and rolling out early stage 5G applications building on our 4G/LTE experience, working with clients (carriers, MNOs, maritime and mobile communications networks) and partners to address 5G opportunities.

5G EXAMPLE: MULTICAST TO EDGE
Figure 1 provides examples of Isotropic applications that illustrate our view of 5G opportunities. It shows cellular backhaul and (secure) media content multicast to an edge content server via Isotropic’s VSAT hub and network.

NETWORK OVERVIEW
The diagram depicts an actual Isotropic 5G test bed deployed with an MNO in the United States. It illustrates two hybrid network scenarios that can be implemented separately or simultaneously on the same Isotropic network:

- Edge Multicasting (Figure 1, bottom left): A 5G macro/metro cell, or gNB in 5G nomenclature, has its own terrestrial connectivity to the CN, illustrated as Internet connectivity that is augmented by a satellite network.
- Remote Tower Backhaul (Figure 1, top left): A 5G micro cell is remotely located beyond the reach of affordable terrestrial connectivity. It relies on two-way satellite backhaul connectivity via Isotropic’s Earth Station to connect to the Cloud.
ISOTROPIC EARTH STATION

Video content sources enter the network at Isotropic’s Earth Station facilities from the Internet CDN (or Cloud) via an edge router, in this example with a firewall. A switch connects to security device(s) and to a content server, which manages content delivery (security, encryption, streaming, authorizations) to the edge. It also switches traffic between the VSAT hub and edge router at Isotropic’s Earth Station. In this example, Isotropic’s satellite forward link channel from the VSAT hub provides 200 Mbps of capacity available to satellite terminals located at cell towers within the national satellite footprint. A 40 Mbps portion of the capacity can multicast 17 popular livestream TV channels (ESPN, Disney, ABC, NBC, etc.).

5G MACRO CELL

The 3G/4G/LTE cell tower in this example has a terrestrial link to the IP backbone. In migrating to a 5G scenario, we can add the satellite portion, allowing high-quality live TV streams (e.g., HD, 4K, 8K video) to be multicast directly to macro cell towers or 5G base stations (gNB) and enabling huge bandwidth-saving benefits. The diagram shows a separate physical path from a co-located VSAT terminal at the cell tower, which connects over Isotropic’s satellite network to the core/Cloud.

Most of today’s cell infrastructure uses a unicast network. During live TV programs such as sporting events, large numbers of viewers, each requiring an individual unicast program stream (e.g., 2 Mbps), can severely tax the backhaul network capacity. With multicast via satellite, only one stream needs to be sent on the network, which is available for an unlimited number of viewers to join or leave.

In the Figure 1 example, a 5G MNO uses Isotropic’s satellite network to efficiently multicast live TV streams to edge content servers (e.g., mobile edge computing [MEC] servers) at cell tower sites. This frees up capacity between the gNB and the CN that would otherwise be required for requesting and sending individual user (unicast) TV streams. Again, without the satellite multicast network, each user device streaming video would require its own live stream from the gNB to the core and/or Cloud.

By multicasting the same video to many cell towers, the 5G provider avoids the need to provision terrestrial capacity to each tower, thereby saving 40 Mbps of downstream terrestrial bandwidth per cell. An MNO could leverage these savings across hundreds or even thousands of base stations. Compared with satellite, when using a terrestrial network—even if all cell tower routers were multicast-enabled—the 40 Mbps of physical capacity would have to be added for each tower at incremental cost.

By reducing traffic demand and server/processing requirements, multicasting can deliver superior user video experiences with reduced risk of jitter, picture buffering and similar issues that could otherwise be introduced by transmission of the content from the Internet and through the CN.

Popular applications and nonlinear video content can also be efficiently multicast to edge content servers, such as an MEC server, where it is cached closer to the end user and therefore served faster to improve users’ quality of experience (QoE).
5G SMALL, MICRO CELL

The 5G small cell in the diagram illustrates another scenario. For rural operators and cell sites in low-density areas, the cost of provisioning terrestrial backhaul connections can be high compared to the potential subscriber revenue, and available terrestrial capacity may be limited. For these situations, a satellite two-way terminal is deployed at the cell site (gNB).

Satellite terminals in the 5G small cell (gNB) example can each backhaul up to 200 Mbps to the Isotropic Earth Station, and from there onto the MNO 5G CN, the Internet or both. In this example, 160 Mbps of satellite capacity can be shared as a virtual resource across multiple micro cell (gNB) nodes to support connectivity to the Cloud or MNO’s 5G CN.

The micro cells can also gain the same benefits of multicasting and caching that macro cells enjoy in the earlier example.

Similar satellite extension and multicast solutions can be implemented for enterprise 5G networks—for example, to provide 5G to a company, port, transportation hub, stadium, disaster area or similar localized 5G service area.

**BENEFITS:**

The 5G-ready satellite network in these examples offers key benefits to network operators:

- Fast deployment—of 5G small/micro cell sites
- Reach—deployment into remote or “unwired” locations
- Redundancy—and backup capacity for terrestrial network connectivity to the 5G base station
- Overflow capacity—for carriage of peak period latency-insensitive traffic
- Scalability—Satellite one-to-many bandwidth costs do not increase as more gNB receive sites are added. It can scale up cost efficiently to thousands of edge content server locations with zero incremental increase in recurring bandwidth costs. Satellite network architecture allows pools of capacity to be shared and prioritized across several or all cells in the satellite beam coverage; this is unlike terrestrial wireline infrastructure, which requires a fixed last-mile connectivity infrastructure investment for each site.
- Cost-insensitive to distance—Unlike terrestrial, satellite transport costs do not rise with increasing distance between nodes as long as they are within the same wide satellite beam coverage.
- Efficient multicast/content edge cache savings—By multicasting popular livestream and cacheable 5G media content to the edge over the Isotropic satellite network, MNOs can reduce their costs for connectivity and/or user QoE.

*In the demo, Isotropic powers the satellite link with its existing network and provides an end-to-end managed service between the remote and the test bed.*
MANAGING TODAY’S 5G-READY SERVICES MORE INTELLIGENTLY

Consumers are demanding greater levels of connectivity, and their thirst for bandwidth and speed is escalating. The demand for mobile bandwidth is huge and could outstrip supply as growth and 5G expectations are placed on networks.

We have discussed how integrating satellite networks into a hybrid network infrastructure can bring big benefits for network operators in terms of bandwidth savings, performance, redundancy and quality of service (QOS).

As new technology and standards including 5G come online, understanding bandwidth capacity availability and distribution models across multi-use and hybrid networks is more critical than ever. Managers of networks that serve remote sites often face unique challenges:

- Bandwidth providers can still struggle to provide reliable, cost-effective solutions that enable a frictionless user experience.
- Lack of consistently available bandwidth, plus latency issues and excessive lag times, can plague remote Internet access experiences.
- In many cases, bandwidth is allocated inefficiently due to a lack of meaningful user and usage data. Providers lack easy access to information they could use to develop and manage better user service plans and data products.
- End users in infrastructure-challenged access areas can still struggle with the perennial issues of long lag times, latency issues and excessive fees for unforeseen data use overages

To address these challenges, MNOs/MVNOs need to better understand and optimize their bandwidth for availability, cost and efficiency. With the scarcity of scalable, cost-effective solutions that enable a frictionless user experience, service providers can struggle to keep pace today.

COMPLETE VISIBILITY FOR A MORE SOPHISTICATED NETWORK.

Datadragon is a bandwidth management and service platform from Isotropic that enables unprecedented levels of application-level transparency, optimization and personalization across any single, multi-use or hybrid network. Datadragon allows providers to move beyond current data models and work with their customers to create smart plans based on actual usage.

Datadragon
Smarter Bandwidth. Intelligent Service.
SHAPING THE FUTURE OF BANDWIDTH

Datadragon's artificial intelligence (AI) and built-in analytics learn usage patterns, then shape and deliver access to data based on available bandwidth streams from all terrestrial and satellite-based platforms. Datadragon provides users with the amount and quality of connectivity they need for their applications.

From checking email to streaming Netflix, users no longer need to suffer through the frustrations of dropped connections and slow lag times — and providers can now analyze and efficiently distribute bandwidth, creating opportunities for increased revenues from surplus availability. Datadragon operates on three core principles:

HOW DATADRAGON WORKS

I. **INCREASE VISIBILITY** by providing users with a real-time picture of bandwidth utilization, down to the application level, across all single, multi-use and hybrid networks.

II. **OPTIMIZE ACCESS** by giving users control. Let them see, allocate and purchase bandwidth based on their unique needs.

III. **REDUCE FRICTION** through Datadragon's analytics and AI. Provide Internet access that simply “works” by allocating bandwidth automatically based on user history and demand.

Datadragon solves inherent issues found when scaling network visibility solutions with flow data based on NetFlow and IPFIX. Datadragon’s learning classification engine reclassifies a flow at a minimum rate of once per second through a patented solution. This provides unprecedented network visibility in terms of scale, cost, flexibility, accuracy and real-time usability.

The Datadragon platform operates in a fully software-based virtual appliance that can be integrated via API/PCRF and deployed across different points in a network, so users can apply automatic assurances of capacity to every network flow dynamically based on real-time usage.
SMARTER BANDWIDTH. BETTER SERVICE.
Through Datadragon’s proprietary bandwidth monitoring platform, Isotropic’s clients can now provide their customers or end users with real-time visibility into their Internet usage so that clients can proactively analyze and address everything from service requests to billing issues.

Datadragon’s patented algorithm, paired with state-of-the-art AI technology, offers detailed insights into day-to-day user activities and gives our clients the ability to optimize and prioritize bandwidth allocation according to their end users’ needs.

With Datadragon, our goal is to provide clients with a deep understanding of their bandwidth usage patterns and user trends as well as with tools to help them more efficiently deliver high-quality service and better user experience. Strategic insights into end-user bandwidth usage can provide opportunities to create new revenue streams and increase network profitability.

LOOKING AHEAD
Isotropic is demonstrating its commitment to helping clients prepare for 5G rollouts by playing an active role in researching, testing and validating 5G/VSAT integration.

Call or contact us at Isotropic to get more in-depth information, to discuss your implementation or to explore how Datadragon can enhance your operation.
ABOUT ISOTROPIC

Isotropic Networks, Inc. (Isotropic) is a global provider of satellite Internet services and network management solutions. With the best uptime in the satellite industry, we deliver unrivaled certainty for high-risk, high-pressure operations for diverse industries including Oil and Gas, Maritime and Enterprise Solutions.

Isotropic is built on high standards for troubleshooting and solving technically complex problems with the latest technologies. Our team of highly trained hardware and software engineers delivers personalized services and solutions that support our clients when and where they need it most — now and into the future.

Isotropic is connecting the planet and continually raising the bar for what satellite connectivity can be.