NSR
NORTHERN SKY RESEARCH

Telecom-Satcom Digital Network Integration

The Keys to New Market Opportunities

March, 2022

ABSTRACT

As a digital transformation journey focused on the customer experience is underway, new opportunities are arising for satellite players to join terrestrial and wireless carriers who have already gravitated towards multi-domain strategies.

Current disruptions in space also feed this window of opportunity driving the satellite sector to accelerate a transformation process in virtual ground networks. What's more, virtual ground systems[1] can also enable satellite providers to work more effectively within the established global communications ecosystem, thereby growing an increased market share in digital services and expanding their service offerings in tandem with terrestrial providers. Such a shift is vital for satellite and telecom players to jointly tap into new growth opportunities such as servicing remote enterprise networks, cloud extensions and eventually 5G.

> *Disruptions in space provide a window of opportunity for the satellite sector to accelerate a transformation process in virtual ground networks, with the goal of achieving seamless digital integration with telecom carriers*

This white paper analyzes the market opportunity and dives into five synergetic technology enablers that satellite operators and service providers need to adopt and adapt to be able to achieve a seamless interplay with telecom carriers and enterprise users. These are: Carrier Ethernet Networks, Service and Resource Orchestration, Digital IF and Universal CPE.

Seeking agile, software-driven integration with the evolving needs of telecom carriers, enterprise users and cloud providers is vital for satcom growth. While satellite players need to play catch-up in virtualization technology, the core elements of multi-domain virtualized operation are accessible, as they have been standardized and adopted in the carrier ecosystem.

[1] NSR White Paper "Satellite Ground Network Virtualization"; March 2020: https://www.nsr.com/wp-content/uploads/2020/03/NSR-White-Paper-Ground-Network-Virtualization-March2020-FINAL.pdf

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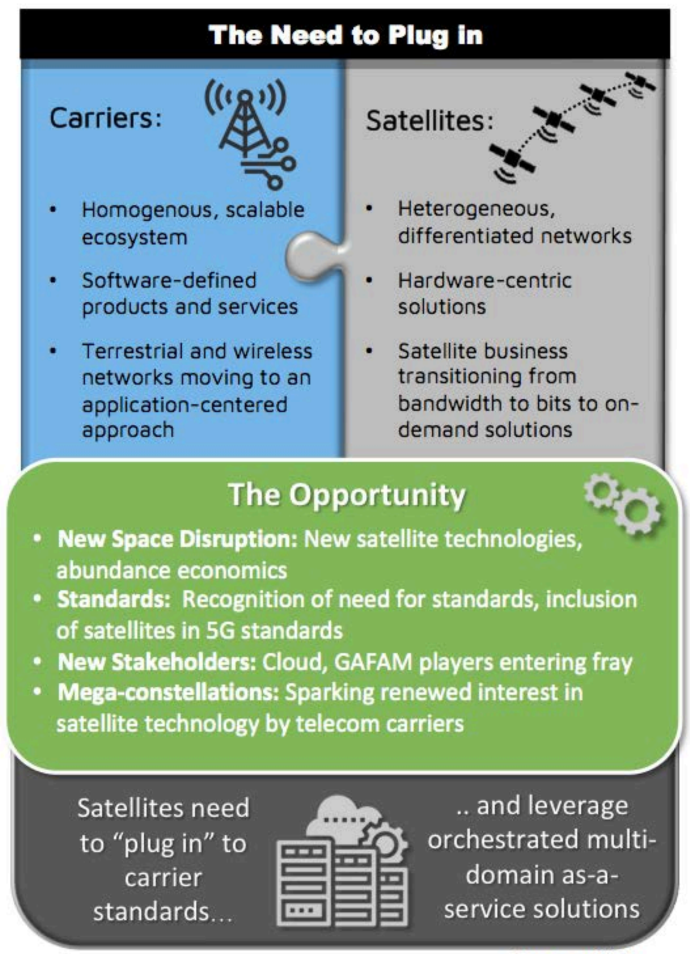
Introduction

The Evolution of Satellite and Telecom Networks

Since its inception in the late 1950's, the satellite communications sector has consistently played important roles in the evolution of global telecommunications and entertainment networks. While generations of increasingly powerful satellites enabled mass-market retail applications such as DTH and residential satellite broadband, satellites' main contributions to the global telecom and entertainment industries have largely happened "behind the scene" as satellites took on support roles in hybrid networks. From efficiently delivering TV distribution to broadcasters and cable headends, to enabling international interconnections for PSTN[2] carriers, to expanding the footprint of enterprise, government and cellular backhaul via VSAT networks and more; the adaptability of the satellite industry throughout transitions and disruptions has been remarkable.

In spite of a proven track record of adaptability, satellites' share in the overall telecom market has been shrinking, representing approximately 1% of the overall global telecom market.

The global telecom market size of goods and services was estimated at USD 2.7 trillion in 2021, projected to grow at a CAGR rate of around 6%, reaching a $3.4 trillion[3] in size by 2025. In a broadband-empowered society, telecoms have a multiplying effect, as networks are vital to the functioning of virtually every economic sector. Distinct studies have consistently found a strong correlation between the availability of high-quality telecom services –both fixed and wireless– and GDP growth. The mobile industry alone contributed 4.4 trillion U.S. dollars to global GDP in 2020, accounting for over 5 percent of global GDP overall[4].



Source: NSR

One of the reasons for satellites' shrinking role in the overall telecom market is that, while satcom has exhibited network adaptability, satellite networks have largely operated as islands of technology, often leveraging proprietary solutions focused on

[2] PSTN stands for Public Switched Telephone Network, or the traditional circuit-switched telephone network
[3] Research and Markets Telecom Global Market Report 2021: COVID-19 Impact and Recovery to 2030 https://www.researchandmarkets.com/reports/5240294/telecom-global-market-report-2021-covid-19
[4] https://www.statista.com/statistics/1100651/worldwide-mobile-industry-contribution-gdp/

solving specific issues. Unlike satellite networks, telecom networks have long operated under the principles of open standards; enabling liquidity of products and services across a rather homogeneous, large and scalable global ecosystem.

Satellites' historical reliance on proprietary solutions is linked to the need to differentiate in an environment defined by scarcity economics, as the high cost of satellite capacity remained a growth inhibitor. This situation, however, is now prone to change because of the abundance of investments in space assets driving need for expansion. Bandwidth-abundant software-defined payloads, LEO/MEO/GEO multi-orbit and multi-band satellite architectures, advancements in electronically steered antenna technology, and developments in the cloud are changing the old paradigm, fostering the need to more effectively plug into the larger telecom grid. Seamless integration with telecom carriers will enable growth.

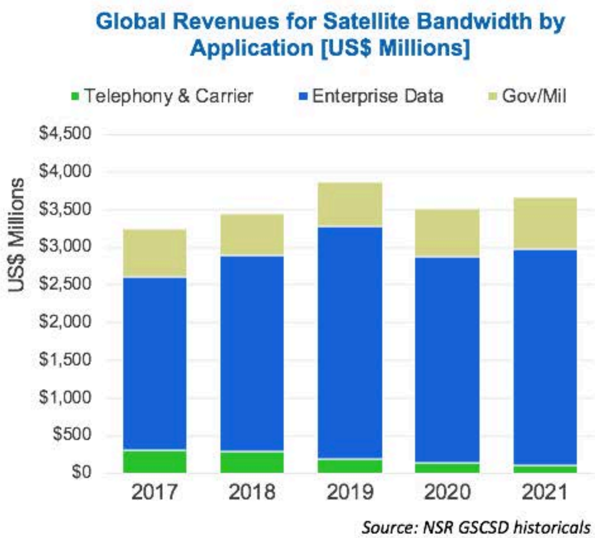
Business Challenges and Solutions

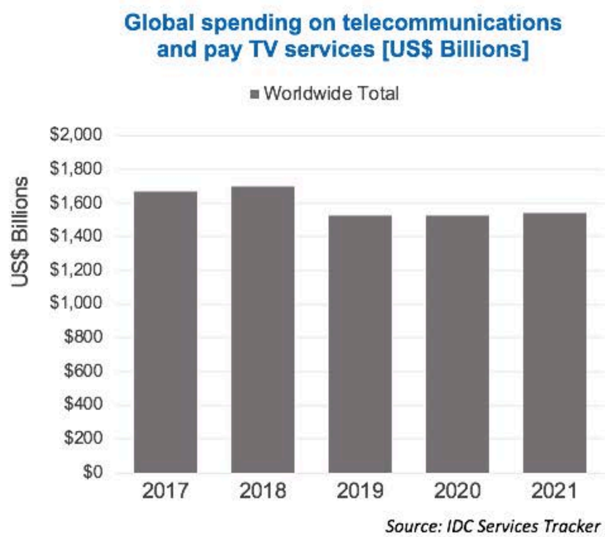
Recent Growth Challenges for Telecom and Satellite Players

Telecom and satellite players that provide connection services to enterprise users and consumers operate at quite different levels of market size; yet both sectors have exhibited similar growth challenges in recent years. Global revenues for telecommunication services, recorded by NSR and IDC respectively on the satellite and telecom sectors, illustrate a slow-growth or stagnant revenue pattern over the past 5 years. The economic impact of Covid-19 appears to have played a relative role, particularly for telecom, as global growth challenges preceded the pandemic.

Service revenues collected by satellite operators via wholesale capacity leases have ranged between $12 and $13 billion worldwide in the 2017-2021 period. When zooming into the main applications that interplay with telecom carriers, capacity revenues have oscillated between $3.3 and $3.8 billion, representing around 30% of global service revenues for satellite operators. These Satcom applications that are carrier targeted include telephony extensions of telecom PSTN networks (an eroding business) together with satellite capacity used to complement carrier connectivity for government agencies and military users; but the main carrier-linked revenue contributor to satellite operators' business is through servicing a set of data applications bundled as "enterprise data" in NSR's global assessment of supply and demand research study[5]. These enterprise data applications range from enterprise VSAT networks to wireless backhaul (in remote or hard to reach locations) to IP trunking and backup/restoration services.

[5] NSR's Global Satellite Capacity Supply & Demand Research Report (in its 18th edition at the time of this paper writing) - https://www.nsr.com/?research=global-satellite-capacity-supply-and-demand-18th-edition





Research firm IDC records similar recent growth challenges in the carrier sector, in spite of carrier service revenues being two orders of magnitude larger than satellite capacity revenues. According to IDC's Worldwide Semiannual Services Tracker[6], global spending on telecommunications and pay TV services have oscillated between $1.5 trillion and $1.7 trillion over the past 5 years, with revenue peaking in 2018. Revenue stagnation for carriers is largely linked to competition from Internet giants providing over-the-top services to consumers, and cloud-based applications and IT services provided to enterprise users.

Growth Opportunities in Enterprise-Class Services

Despite recent challenges, NSR believes that – with the right execution- there are at least three attractive enterprise-class opportunities for satellite and telecom carriers to jointly go after, particularly in remote and underserved locations: Carrier Ethernet Networks, Cloud Extensions and, later, 5G applications.

While the largest portion of IT spending by enterprise users is communications services, dominated by carriers, the global enterprise services market is valued at around $4 trillion annually, according to Gartner[7]. This means that, despite carriers' revenue growth challenges, enterprise services remain a growth opportunity, especially when considering the low proportion of enterprise in telecom operator revenues (15-25% according to sources). However, the main challenge that telecom players face for tapping into this huge enterprise services marketplace is that telcos and MNOs are often bypassed on digital services because Internet giants have managed to deliver powerful cloud servicing platforms with strong network externalities.

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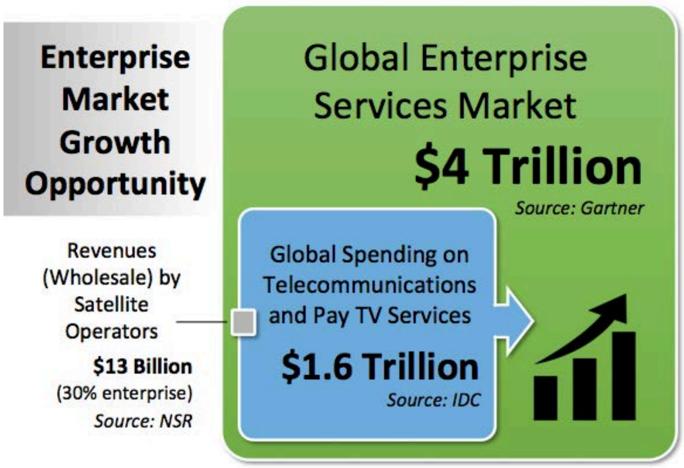
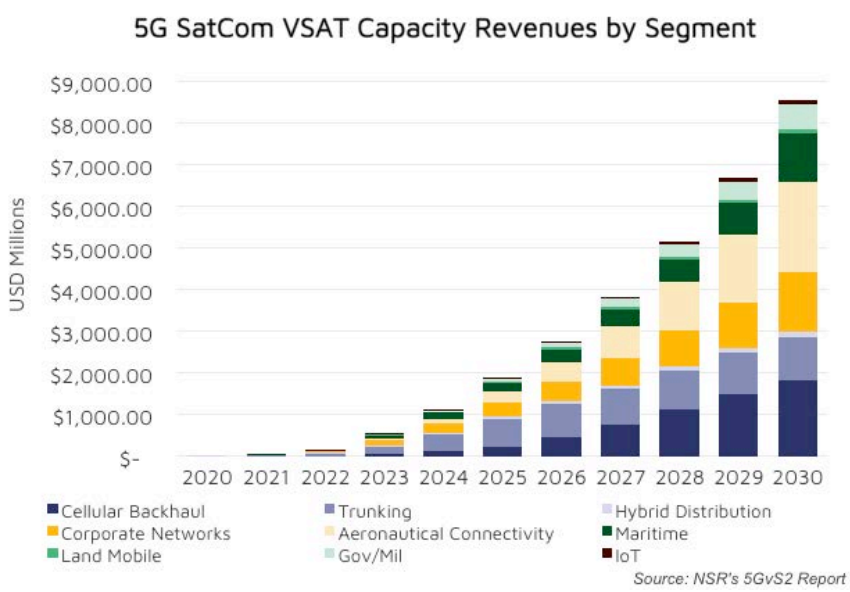
[6] IDC Worldwide Semiannual Telecom Services Tracker - Press Releases - https://www.idc.com/getdoc.jsp?containerId=prUS48362921
[7] Gartner PR - https://www.gartner.com/en/newsroom/press-releases/2021-10-20-gartner-forecasts-worldwide-it-spending-to-exceed-4-trillion-in-2022

For carriers to increase revenue participation in the enterprise market, they need to play to their strengths. Ownership of wide-area networks and granular network capillarity via expanding points of presence close to enterprise customers are key advantages that telecom carriers can leverage. Joining forces with satellite service providers and operators thus becomes natural for expanding managed services solutions to distant or hard to reach locations, as showcased by a recent wave of distribution partnerships between major telecom operators with emerging LEO players. While network footprint expansion is a strength for telecom and satellite players joining forces, it will not be a sufficient condition for success. It also will be key for them to seamlessly interoperate their systems in automated ways, while providing enterprise users with increasing levels of control via fine programmability of digital communications services.



In the longer term, 5G will become another key innovation driving the multi-domain and multi-technology play between carriers and satellite players. With a much wider scope than previous generations of cellular technology, 5G unlocks new uses by offering a framework for integrating all communication technologies. Conceived as a 'Network of Networks,' 5G allows non-3GPP technologies (including satellite) to be seamlessly integrated in the 5G core and the edge. The inclusion of Non-Terrestrial Networks (NTN) into the definition of 5G represents indeed an opportunity for satellites to directly communicate with 5G mainstream devices (cellphones, IoT), thus potentially unlocking a massive addressable market, leveraging global scale distribution. Interoperability between satellite and carrier network systems will be a necessary first step towards the more expansive goal of satellite support for 5G.



The Digital Transformation of Carrier Networks

A well established and growing number of service providers and technology suppliers are deploying MEF[8]-compliant Carrier Ethernet Networks (CEN) to deliver on the promise of enhanced managed services, leveraging software-defined and network functions virtualization (NFV). Since virtually all LAN traffic is on Ethernet, using the world's dominant networking standard becomes the natural choice for carriers and IP service providers to reduce the total cost of ownership (TCO) in multi-domain networks, with automated, end-to-end services. CEN extends and expands the reach of Ethernet from LAN to MAN, WAN and RAN so that services can seamlessly be provided across multiple network environments via Ethernet-based interfaces.

The adoption of CEN with underlying NFV[9] and SDN[10] building blocks is key, as these are based on a comprehensive set of concepts and standards with well-defined demarcation points for the seamless interplay. Given that standards are supported and adopted by the world's largest telecom and technology players –including a few leading satellite players– it becomes a smart and safe move for other satellite ecosystem players to collectively piggyback on such movement, to become better integrated with the large carrier market. This means that satellite stakeholders, including satellite or teleport operators and technology vendors, need to fully embrace the virtual network infrastructure paradigm.

MEF Members - Partial List	
Service Providers	**Technology Suppliers**
AT&T	Amdocs
BT	Aruba HP
China Telecom	Ciena
Claro	Cisco
Deutsche Telekom	Comarch
Digi	Connected2Fiber
Docomo Pacific	Datacom
GTT	Ericsson
INTELSAT	Fujitsu
Lumen	Huawei
Microsoft Azure	Infinera
NTT Communications	Intraway
OneWeb	Juniper Networks
Orange	Kratos
PCCW Global	NEC Netcraker
SES	Nokia
TATA Communications	Oracle Communications
Telefonica	RAD
Telesat	ServiceNow
Telstra	Spirent
Verizon	VMware
Vodafone	ZTE

When telecommunication networks become virtualized via CENs and inter-work in programmable and automated ways, they can also strike synergies with cloud network resources, both public and private and their extensive digital marketplaces. CENs can indeed become the transport vehicle for cloud extensions, particularly towards the edge; thus enabling upsell and low-latency access to powerful ecosystems of collaboration, networking and data analysis services. There are many advantages when being actively engaged in cloud-enabled ecosystems, with inherently powerful multi-sided network effects. Satellite MEF-compliant networks can thus enable multi-domain services not only across their terrestrial points of presence (PoPs) that interface with telecom carriers but also all the way to the edge devices.

[8] Metro Ethernet Forum (MEF) is a global industry association of network, cloud, and technology providers
[9] Network Function Virtualization (NFV) is a way to virtualize network services
[10] Software-Defined Networking (SDN) is an approach to networking that uses software-based controllers or application programming interfaces (APIs) to communicate with underlying hardware infrastructure and direct traffic on a network

A New Carrier-Satellite Ecosystem

Towards the Automated and Orchestrated Multi-Domain Network

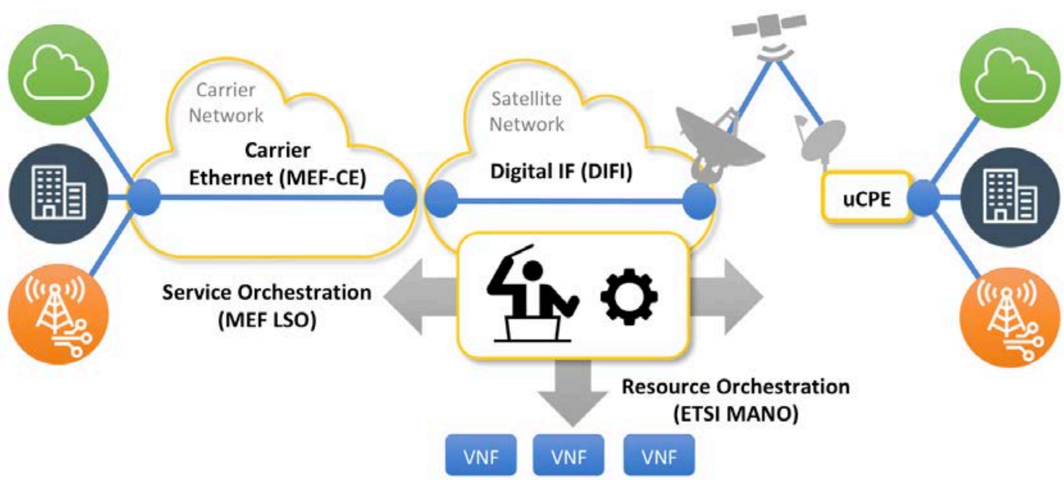
Massive investments and technology disruptions in space initiatives provide a fertile ground for satellite networks to increase participation in the global telecom industry through better integration with telecom and wireless carriers, a shift from bandwidth scarcity to abundance and an associated decrease in bandwidth cost. An architectural shift is required; however, because traditionally siloed, heterogeneous satellite ground networks today are not ready to deal with the range of dynamic processes needed to support these growth opportunities.

Five key and inter-related technology elements are necessary for satellite/carrier integration and to capture a larger share of the growth opportunities of programmable enterprise-class services. The five elements are described here at a high level, NSR encourages readers to refer to the respective standard specifications for more details.:

1. Carrier Ethernet Networks (MEF CE)
2. Service Orchestration (MEF LSO)
3. Resource Orchestration (ETSI MANO)
4. Digital IF (DIFI)
5. Universal Customer Premise Equipment (uCPE)

By embracing these technology elements, service providers will be able to shorten the time to revenue, simplify and automate service delivery across multi-domain networks, scale on demand to meet changing market conditions and lower the Total Cost of Ownership (TCO).

Telecom-Satellite Integration Elements



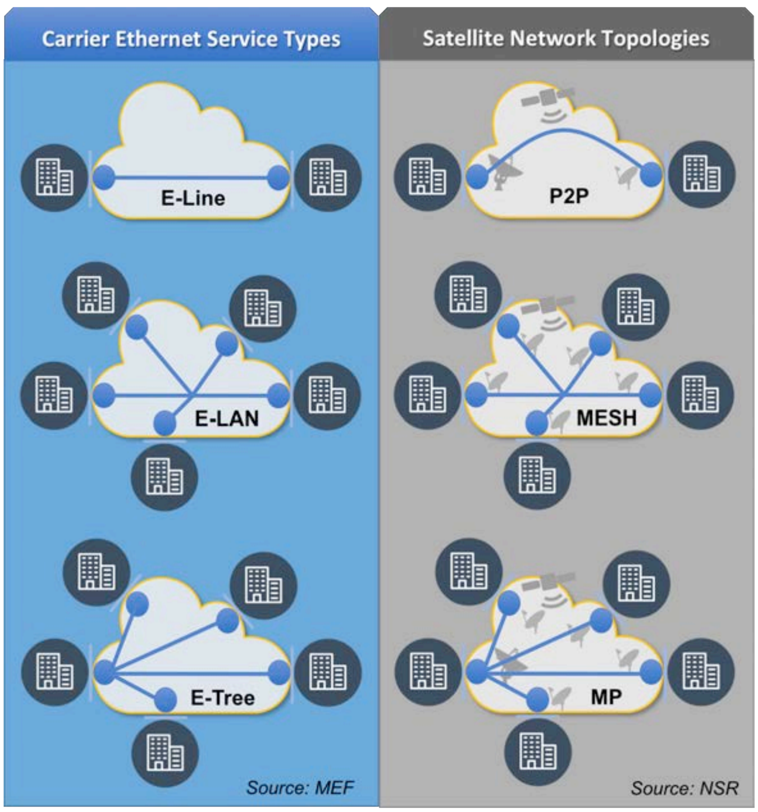
Source: NSR

1. Carrier Ethernet (MEF CE)

Carrier Ethernet (CE) standards are defined by the Metro Ethernet Forum (MEF). MEF's CE standards define technology-agnostic layer-2 services that can be used across core-network, transit, and access service providers for backbone, backhaul and last-mile services, while also easing the inter-play with cloud access. The CEN standards thus allow end-to-end, multi-provider, on-net and off-net connectivity, including services consumed by enterprise users.

MEF 3.0 (latest version at time of this paper writing) comprises a comprehensive set of over 80 standards published. Here we will focus on a few that are key to enabling MEF-compliant "subscriber"[11] and "operator"[12] services. MEF makes a distinction between "service level" and "operator level" specifications based on whether services are provided to enterprise users (subscribers) or between service providers (operators), although many characteristics in the specifications apply similarly to both service types.

The service level specifications define the performance objectives for the service delivered to the end user (subscriber). Terms such as link delay, frame loss, delay variation and availability are defined at this level. Bandwidth profiles are also another important aspect of the subscriber experience, both in terms of the bandwidth requirements and the associated classes of service.

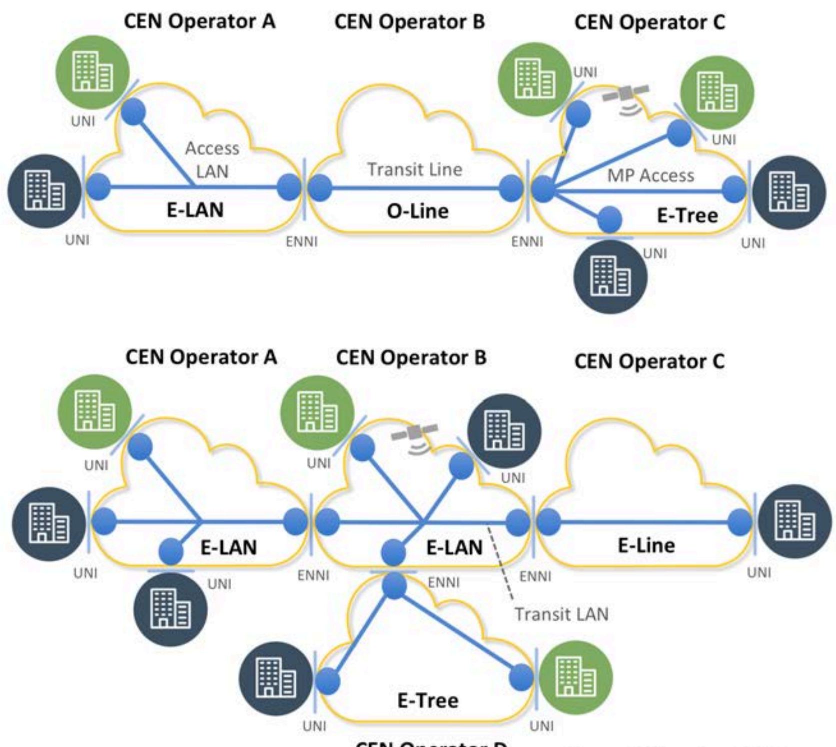


For the subscriber Ethernet service definitions, MEF CE has three main types of services, which interestingly resemble commonly used topologies in satellite networks:

- E-Line: Point to point (P2P)
- E-LAN: Multipoint (MP)
- E-Tree: Rooted Multipoint ("star" hub-and-spoke)

[11] Key subscriber services standards (MEF 3.0): MEF 10.4 (service attributes) and 6.3 (service definitions)
[12] Key operator services standards: MEF 26.2 (service attributes) and MEF 51.1 and MEF 62 (service definitions)

Each of these service types have their corresponding port-based variants in the VLAN domain: EPL and EVPL (E-Line), EP-LAN and EVP-LAN (E-LAN) and EP-Tree ad EVP-Tree (E-Tree)



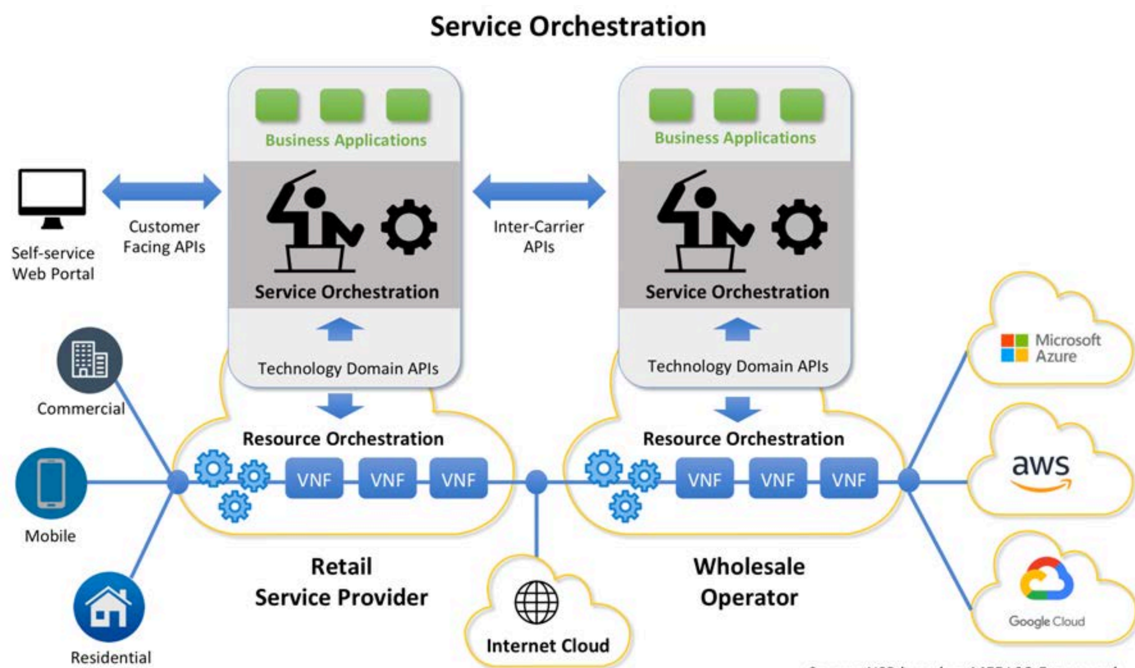
Source: NSR based on MEF CE Specs

On the operator side, there is a similar set of service attributes as those defined at the subscriber level but with a few additions to allow complex business relationships. One example is "class of service mapping," so that "service class of service" markings are consistently treated end-to-end when traversing distinct, multi-domain CE networks.

For the Operator Ethernet service definitions, there are three general services, similar to those defined at the subscriber level: O-Line (P2P), O-LAN (MP) and O-Tree (Rooted MP).

2. Service Orchestration (MEF LSO)

The provisioning and delivery of CEN services requires standardized APIs for automating functions to meet service ordering lifecycles and to improve the customer experience. CEN operators and service providers need an automated, standardized way to provision and reconfigure services in seconds, not days; and seamlessly across multiple partner provider networks. LSO (Lifecycle Service Orchestration) is a set of MEF-defined specifications enabling standardized, multi-domain service lifecycle orchestration. LSO comprises a set of SDKs containing APIs, tools, and underlying standard documentation for frictionless multi service provider commerce.



Source: NSR based on MEF LSO Framework

The service orchestration functionality traverses the customer, service provider and partner domains. If a service provider is trying to provide connectivity service on a global scale and does not have a global footprint, an LSO-enabled multi-partner setup can enable the service provider to quote for such services in areas indirectly reachable and to turn up services via standardized API consistently across all its partners.

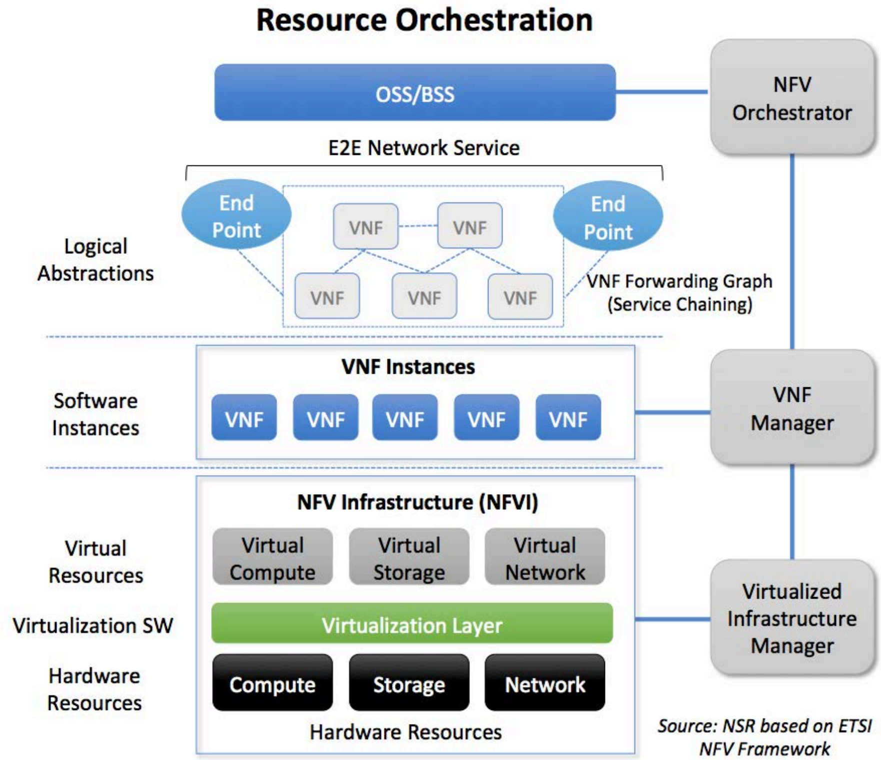
3. Resource Orchestration (ETSI MANO)

Service orchestration for the dynamic provisioning, activation and reconfiguration of services drives the need to go down to specific controllers and various network component layers within each operator's network. This process is called resource orchestration, which is defined by another set of standards. While LSO provides a framework for "East-West" multi-player *service* orchestration, *resource* orchestration, in contrast, deals with the "North-South" interactions within a service provider, down to the SDN controllers and NVFs.

ETSI Management and Orchestration (MANO) is a key element of the Network Functions Virtualization (NFV) architecture. MANO is an architectural framework that coordinates network resources for cloud-based applications and the lifecycle management of Virtual Network Functions (VNFs) and network services. As such, it is crucial for ensuring rapid, reliable NFV deployments at scale.

The NFV stack starts at the bottom with the physical compute, storage and network resources. On top of this layer, there is a virtualization layer that abstracts those resources in order to enable dynamic, software-enabled uses. Such a virtualization layer transforms the physical resources into virtual compute, virtual storage and virtual network resources. These virtual resources can then be used to build VNFs, which are the combination of virtual resources into larger logic components, with loaded software images for specific NVF functionality.

The combination of VNFs is called a "Network Service," containing virtual and physical network functions connected by virtual links. This is visually represented by what is called a "VNF forwarding graph," which describes service chains. Finally, those network services are integrated into an end-to-end network service providing functionality.



Source: NSR based on ETSI NFV Framework

The architectural framework for managing the virtual resources includes the following components: The NFV orchestrator (NFVO), the VNF manager (VNFM), and the virtual infrastructure manager (VIM), which respectively interact with the layers described within a network for the orchestration of resources.

4. Digital IF (DIFI)

Virtualization and integration of satellite networks with the carrier and cloud ecosystems inevitably drive the need for convergence and standardization at the IF and RF satellite signal levels.

"Digital IF" is a vital component of the digital ground for the virtual processing of individual satellite carriers (independently from antenna location), both for the transport of data across the core ground network and for quality monitoring or management purposes and extraction of insight from such data. The concept can also be applied for remote stations, where the analog and digital front ends may not necessarily be co-located.

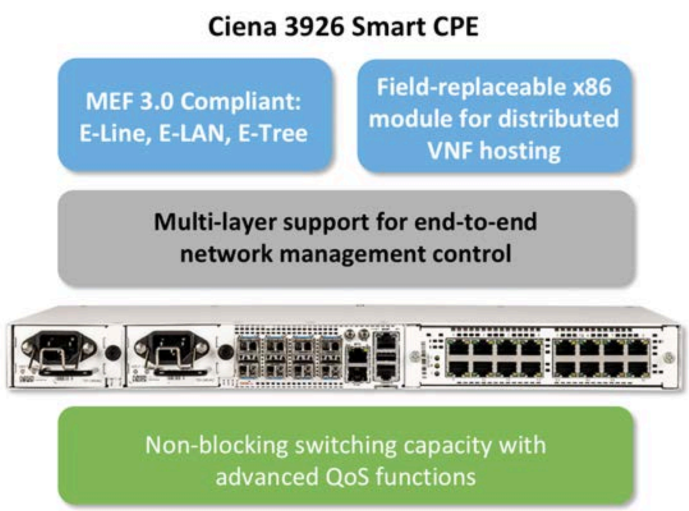
The Digital IF Interoperability Consortium (DIFI) has established an interoperable digital interface at intermediate and radio frequency (IF/RF) spectrum levels, based on digital radio standard VITA 49.2, to replace analog IF signals and avoid vendor lock-in. Widely adopted in the terrestrial wireless space, VITA 49 is a packet-based protocol to convey digitized signal data and metadata (context data) between the digital and the analog RF sections of a radio, the RF-digital interface.

The DIFI Consortium has garnered the participation and support of major players across the global satellite industry, including satellite operators, government agencies and ground segment solutions providers. The first DIFI standard, 'IEEE-ISTO Std 4900-2021: Digital IF Interoperability Standard, v1.0', released in August 2021, has started being specified as a requirement in RFPs. It is available at the DIFI website.

5. Universal Customer Premise Equipment (uCPE) at the Edge

Robust, standard-compliant WAN and LAN demarcation points at the core and edge of satellite networks will enable the initial phase of end-to-end integration between telecom carriers and satellite networks. Nevertheless, in the long term, it will increasingly become important to adopt standards that support the use of universal CPEs at the edge to enable full interoperability among satellite vendors as well. The ultimate promise of open platforms is to foster the emergence of new applications requiring higher bandwidth, performance, and scalability. A better separation between user and network operators via exposable interfaces with partners and customers will enable the seamless connectivity across multiple networks. A self-installable, software upgradeable, fluid network environment free from vendor lock-in will enable a much broader participation of satellites, particularly in key industries such as telecom and aero that have been demanding standardization for years.

The nuances of how satellite spectrum is accessed dynamically make it challenging for the ecosystem to quickly agree on and produce an uCPE but it is key for the industry to decisively walk in such direction across all access schemes (MF-TDMA[13], Dynamic SCPC[14] and SCPC[15]). The easiest access scheme to drive initial interoperability is clearly SCPC. Interoperable SCPC modems existed in the past when Intelsat developed IBS/IDR[16] standards for the interoperability and interconnection of international business lines and PSTN. Nowadays, interoperability needs to not only support the multi-vendor interworking but also the CEN connectivity and virtualization via edge processing. A good analogy of what a CEN modem might look like can be taken from terrestrial equipment vendors like Ciena. Ciena[17] was indeed selected by



Source: Ciena

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[13] MF-TDMA ("Multi-frequency time-division multiple access") is a technology for dynamically sharing satellite spectrum in satcom, particularly for return links with volatile traffic patterns
[14] iDirect-Newtec's Dialog and Comtech's Heights are examples of proprietary dynamic SCPC platforms
[15] SCPC ("Single channel per carrier") refers to using a single signal at a given frequency and bandwidth, providing a dedicated point to point satellite link
[16] Intelsat Intermediate Data Rate (IDR) and Intelsat Business Services (IBS) standards were extensively used in the 1980's and 90's for standardized interconnection of carriers PSTN (voice) and business-line data networks
[17] Ciena-Telesat PR https://www.ciena.com/about/newsroom/press-releases/telesat-selects-ciena-for-low-earth-orbit-terrestrial-network-technology.html

Telesat to enable core network MEF-compliant services at the points of presence (PoPs) and gateway stations for Telesat's future Lightspeed LEO constellation network.

Full Orchestration & Automation

Emphasis towards the digital ground needs to be focused both on driving standardized interconnection between carriers, and also defining demarcation points and APIs which link that connectivity to different types of technologies and services or missions. Multi-domain system orchestration enables participation of satellite networks in Carrier Wholesale ecosystem. To achieve this, digital satellite ground networks need to adopt and integrate the components described above and integrate with existing OSS/BSS systems for the bidding, provisioning, activation and management of service endpoints.

While the satellite sector can piggyback on the described carrier-grade standards exhibiting tremendous momentum, it will also be key for the satellite stakeholders to develop and adopt solutions that bridge the existing gaps between the analog and digital domains.

Space Network SDN: How Close Are We?

As satellite industry players, both space and ground segment companies, are coming to recognize the importance of a software-defined future, the larger communications sector is pushing the boundaries even further into a cloud-based world. Systems interoperability, orchestration and automation are becoming ever more important, and ground systems companies are beginning to react.

For example, at least two companies have announced plans to cloud-enable their Element Management Systems and a few have introduced standalone software versions of traditional ground components. One company, Kratos, has gone beyond these initial steps with its OpenSpace Platform that delivers a fully orchestrated, SDN architecture enabled by MEF, DIFI and other standards raised in this paper.

Three aspects separate the OpenSpace approach: signal processing and mod/demod in software running on off-the-shelf, generic hardware; unified management across the entire network including both virtual and hardware components, and an orchestration controller designed specifically for satellite networks. While the OpenSpace Platform is focused on specific use cases, it has shown at least one path forward towards bringing the satellite and telecom worlds closer together.

OpenSpace™
The Dynamic Ground System

Bottom Line

For carriers and satellite players to leverage joint growth opportunities in enterprise-class services, satellite networks need to virtualize and plug into the digital carrier ecosystem so as to shorten time to revenue. Simplifying and automating service delivery across multiple vendor systems and equipment spanning the WAN, data center, edge and cloud will become essential. To accomplish this, a new level of programmability and abstraction to the network layer will be needed, with advantages including:

- Services enabled across converged, multi-domain data networks
- Standards-driven economies of scale, with "liquidity" and reduction of operating costs
- Reach extension of Carrier Ethernet from LAN/MAN to WAN and RAN in remote areas
- Technology-agnostic, orchestrated network-as-a-service implementation
- Reduced total cost of ownership (TCO) while managing bandwidth, supporting custom QoS and on-demand virtualized applications.

With the right technology elements in place, satellite networks are well suited for next wave of converged enterprise services, extending and enhancing carriers' reach of programmable, on-demand network services.

ABOUT NSR

AHEAD OF THE CURVE

As the satellite & space industry boldly expands in new directions, success is directly aligned with your ability to know where the market is headed and why. NSR helps you get there first.

Founded in 2000, NSR is a global leader in Satellite & Space Market Research and Consulting Services. NSR specializes in the analysis of growth opportunities across four core industry sectors: Satellite Communications, Satellite & Space Applications, Financial Analysis and Satellite & Space Infrastructure.

The NSR team consistently forecasts events and trends well ahead of when they become common industry knowledge. Our clients get results that are broader, balanced, and with the most honest assessment of the impact to their particular business.

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Mr. Placido is an independent consultant with over twenty seven years of international experience in telecommunications and entertainment. Beginning his consulting work with NSR in 2007, Mr. Placido focuses on emerging technologies and satellite markets, and serves as a regional and IP applications expert on satellite communications and regularly provides his analysis and strategic assessment to NSR's consulting practice.

Carlos Placido has conducted numerous analytical and management projects, spanning from global market research studies for NSR, to strategic assessment of emerging technologies, to business development support, R&D and project management. Until 2004, he led a service development team at INTELSAT, where he was responsible for identifying and validating future satcom uses of emerging video and IP data technologies. Prior to INTELSAT, he commenced his career as a network engineer at Impsat (now Lumen) and Telecom Argentina.

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