OpenSpace Platform – Enabling Carrier Ethernet Over Satellite

Deliver E-Line Services Faster, More Dynamically at Scale with Less Cost

Increasing customer demands and the growth of constellation architectures, software-defined satellites, and the tighter integration with terrestrial networks is driving satellite communications towards digital transformation.

Enabling Digital Ground System Operations – OpenSpace Platform

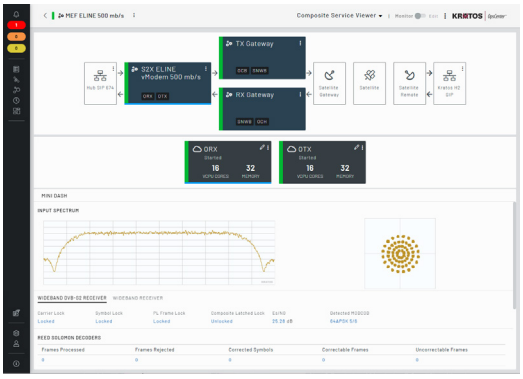
Kratos' OpenSpace® Platform makes this vision a reality by enabling the digital transformation of satellite ground systems to become a more dynamic and powerful part of the space network. The OpenSpace Platform is the first fully virtualized, software-defined, and orchestrated Platform in the satellite industry.

Carrier Ethernet over Satellite

The OpenSpace Platform empowers digital transformation by using MEF's Carrier Ethernet (CE) standard. MEF is a global industry association of network, cloud, and technology providers enabling digital transformation by delivering service standards, Lifecycle Service Orchestration (LSO) frameworks and APIs. Carrier Ethernet connects subscribers to their immediate service provider utilizing standardized service architectures regardless of technology (i.e. copper, fiber or satellite). Carrier Ethernet has a wide adoption in terrestrial telecom networks, enabling providers to interconnect and deliver end-to-end services to their customers.

Benefits of Carrier Ethernet

Carrier Ethernet enables a satellite network to deliver end-user services in the same way that a terrestrial network provider does – enabling standards-based Ethernet private line services regardless of location, while offering the ability to interconnect to the end-customer terrestrial network assets in a seamless manner.



OpenSpace OpsCenter manages and assures performance of E-Line services.

The OpenSpace Platform leverages Carrier Ethernet standards to provide international connectivity services over a mix of terrestrial and satellite provider access links. This opens up new market opportunities to provide more scalable services and faster time-to-revenue than traditional satellite ground systems. High-performance mission-critical satellite services can be provisioned across providers in minutes as opposed to weeks.

Carrier Ethernet Key Markets

- *Telcom Trunking*
- *Cellular Backhaul*
- *Enterprise Network Extension*
- *Defense and Government*

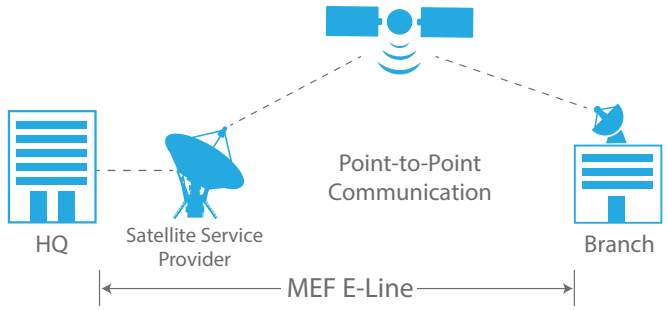
The OpenSpace Platform brings the strengths of satellite to applications including enterprise network extensions, cellular backhaul, telecom trunking, and defense and government use cases. Enterprises can now manage remote branches over satellite as easily as they can with their terrestrially connected equivalents for seamless within the network (on-net) and outside the network (off-net) connectivity.

Carrier Ethernet also allows operators to guarantee Quality of Service (QoS) though standard Class of Service (CoS) agreements enforced across interconnected end-to-end services. This allows satellite network operators to accommodate a terrestrial provider's service-level agreements across satellite-delivered Ethernet private lines. During the provisioning process, the providers can negotiate the traffic classifications and CoS mapping through automated processes using the MEF Lifecycle Service Orchestration (LSO) APIs - providing both providers a seamless way to enable services at scale.

OpenSpace E-Line Service

Satellite operators can now easily offer carrier-grade technology-agnostic layer-2 services that can be consumed directly by the enterprise or used between other access service providers for backhaul, cloud access, or multi-provider end-to-end services.

By using the OpenSpace Platform service providers can easily deliver an E-Line Service – a dedicated, reliable, secure, and cost-effective point to point link over satellite. The OpenSpace Platform supports E-Line Carrier Ethernet Services through its SCPC Service Chain, enabling operators to expand their offerings to remote locations underserved by terrestrial or cellular technologies.



OpenSpace's Carrier Ethernet over Satellite E-Line Providing Carrier-Grade Layer-2 Services.

Through the power of a fully virtualized and orchestrated digital ground system, the OpenSpace E-Line Service is delivered over standard DVB-S2x satellite links using fully virtualized modems capable of delivering Single-Carrier per Channel (SCPC) E-Line connectivity up to one gigabit per second over GEO or MEO links. Located either in the datacenter or deployed at the teleport, each virtualized modem runs on x86-based general purpose compute and does not require any specialized hardware such as Field Programmable Gate Array (FPGAs) or Graphics Processing Units (GPU). Organized as a private cloud and utilizing ETSI MANO standard management and resource orchestration techniques, the OpenSpace Platform allows fully dynamic and automated instantiation of virtualized modems at the gateway at scale.

At the far-edge of the network, the edge terminal employs a virtual modem deployed on x86-based universal Customer Premise Equipment (uCPE) for open and disaggregated networking. The edge uCPE can support OpenSpace virtual modem functions as well as hosting third party applications such as SD-WAN, enterprise network extension functions (such as MPLS L3 VPNs) or SASE applications, offering providers the ability to deliver value-added services for end-users or host multi-vendor applications for their telecom partners on a unified hardware platform.

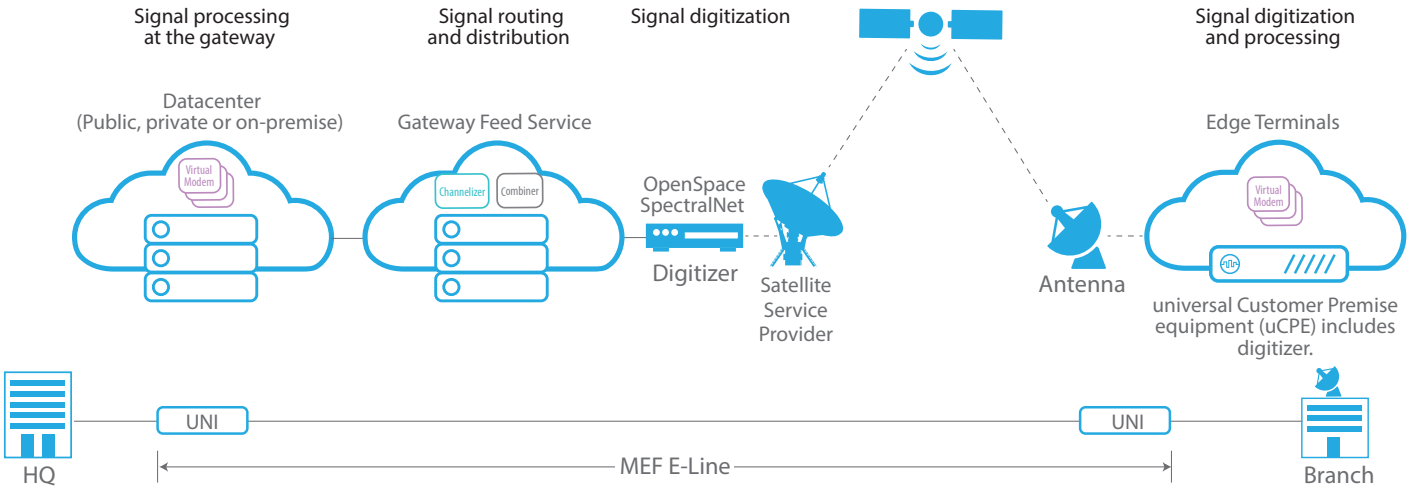
Delivering Connectivity at Scale

The OpenSpace Platform employs software-defined networking at scale using industry open and standards-based service and resource orchestration. Functioning as the nerve center of the platform, the OpenSpace Controller intelligently and automatically deploys fully virtualized E-Line services leveraging MEF's Lifecycle Service Orchestration (LSO) framework. Utilizing the MEF-standard Presto-API northbound interface, Carrier Ethernet services can be activated and de-activated through a providers' service orchestration systems to dynamically deploy services at scale based on demand.

Given new space-layer innovations in the satellite industry around software-defined payloads, it is becoming an operational mandate to seamlessly integrate the ground segment and the space layer together. The OpenSpace Controller can manage Carrier Ethernet lifecycles in tandem with satellite payload operations to dynamically support changes in supply and demand of the satellite bandwidth. This tight coupling of the space and ground layers allow customers to enjoy guarantees in throughput and performance, while giving the satellite operator a streamlined operational experience to ensure service-level agreements with partnered service providers.

Unified Management for End-to-End Services

OpenSpace OpsCenter provides the unified management interface for the Platform and enables service providers to manage the full lifecycle of satellite-based Carrier Ethernet deployments. OpsCenter simplifies implementations by managing all the elements required for service delivery. From the virtualized service-chain elements running in private or public cloud infrastructure down to gateway RF and other physical hardware components in the teleports, OpsCenter provides a comprehensive operational view of all the elements working together and performs monitoring to assure robust customer services.



OpenSpace's End-to-End E-Line Service from the Gateway to the Edge

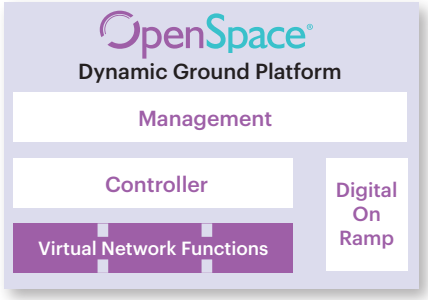
Advantages of the OpenSpace Carrier Ethernet Services:

The OpenSpace platform allows satellite operators and service providers to:

- **Deploy Point-to-Point Services Much Faster**. Deliver and reconfigure Carrier Ethernet services in minutes by automating the service provisioning process all the way from the Operational Support Systems (OSS) to the teleport.
- **Virtualize, Save Space and Reduce Costs.** Process signals virtually at the gateway and edge using commercially available, off-the-shelf x86-based computers. Reduce proprietary hardware costs, vendor lock-in and save valuable rack space.
- **Scale on Demand and Optimize Resources.** Instantiate fully virtualized services as demand grows without the need to over-provision the ground network. Deploy and optimize resources by using them only when needed.
- **Deliver High Throughput.** Provide Carrier Ethernet services over satellite at rates over 1 Gbps to support high bandwidth applications.
- **Enable Fully Automated Satcom Links.** Integrate OSS and Service Orchestration (SO) systems directly with the OpenSpace Platform by using MEF's standardized API interface to enable integrated lifecycle automation for satcom links.
- **Seamlessly Integrate with Carrier Networks.** Interconnect seamlessly with global carrier networks and enable the expansion of coverage to hard-to-reach areas best served by satellite.
- **Support for Cloud-Centric Operations.** Deploy fully virtualized Carrier Ethernet services flexibly in public cloud, private data center or hybrid cloud environments, enabling predictable operational expenditures to grow with service demand.

Enabling Fully Virtualized Digital Ground System Operations

The OpenSpace platform delivers Carrier Ethernet service across a completely digital end-to-end solution. Comprised of a fully digital gateway solution, the Platform provides digitizers to route IF signals from antennas across the ground system to generic compute infrastructure providing digital signal and packet processing. The fully digital and software-based approach to the Platform, enables the system to be deployed in a single teleport, or scaled across multiple teleports and data centers depending on service scale requirements.



Kratos' OpenSpace family of solutions enables the digital transformation of satellite ground systems to become a more dynamic and powerful part of the space network. The family consists of three product lines: OpenSpace SpectralNet for converting satellite RF signals to be used in digital environments; OpenSpace quantum products, which are virtual versions of traditional hardware components; and the OpenSpace Platform, the first commercially available, fully orchestrated, software-defined ground system. These three OpenSpace lines enable satellite operators and other service providers to implement digital operations at their own pace and in ways that meet their unique mission goals and business models.

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