Satellite Ground Segment: Moving to the Cloud

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NSR
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Introduction: A Foundational Shift

The satellite industry is poised at the convergence of multiple trends from the wider ICT ecosystem. Taking cues from its influence as an enabling technology in other industries, only in recent years has Cloud Computing emerged as influential in the satellite world - in the context of efficient and automated delivery of business value to satellite customers, whether in Earth Observation or Communications.

Much activity has focused on the "space" segment, ranging from investments and announcements related to new technology such as non-GEO HTS constellations, software defined radio, network function virtualization, and flat panel antennas, amongst others. Here the Cloud is largely seen as the foundational layer for the industry to morph into a complex arena for flexibly dynamic networks that are interoperable across layers and applications.

In comparison, the "ground" segment in the industry is just beginning to ramp up, with relatively slower developments, in part due to the siloed nature of advancements at a components and sub-systems level. It is only now that the wider Big Data industry recognizes a market gap in the satellite value chain, one that it is well positioned to address. At the same time, traditional satellite companies realize the critical role that Cloud Computing will play in ensuring their businesses remain competitive.

The Earth Observation market is continuously evolving, driven by downstream non-data segments. With a lower barrier to entry, new-space EO players are open to adopting alternative solutions such as on-board processing, optical satcom, and more importantly, virtualized ground stations and Cloud-based systems. This is driven in particular by the need for EO satellite operators to focus capital expenditure on manufacture and launch considerations, thereby presenting an opportunity for innovations in the downlink segment.

A Market in Transformation

For the Satellite-based Earth Observation market, two key segments are immediately apparent as applicable areas for such Cloud native ground systems: **data downlink, and geospatial analytics.** As outlined in NSR's ***Commercial Satellite Ground Segment, 4th Edition*** report, despite nearly 2,400 EO ground terminals expected to be shipped by 2028 cumulatively, the growth in demand is forecast to grow only at a CAGR of 3.3% while the associated revenue opportunity is much lesser, at 0.8% through the next 8 years.

EO ground service providers are currently revamping/augmenting their existing capabilities, leveraging virtualized ground services built on shared infrastructure, which is expected to slow demand for CAPEX-heavy ground equipment going forward.

Solutions on the market are more varied than ever before: from shared/virtualized infrastructure by RBC Signals or Infostellar to the traditional ground station partners such as KSAT and SSC. The former bringing in multi-mission, multi-tenant, flexible ground infrastructure on a service basis that saves CAPEX for the satellite operator, while the latter offers a full ground network solution leveraging their existing ground stations. In other cases, satellite operators may also prefer to develop a proprietary network of ground stations to ensure efficient operations and data downlink.

AWS Ground Station is another such solution from a major Cloud Service Provider (CSP) that leverages its global existing infrastructure (currently eight ground stations and growing) to provide satellite operators a fully managed Cloud-based ground station service. It allows for connections with satellites in LEO and MEO and enables EO SatOps customers to command, control, and downlink data from their assets in space.

Bringing Down EO Data in the Cloud

Multiple stakeholders in the satellite communications market, ranging from teleport/gateway operators and satellite operators to service providers and ground system vendors are expected to employ best practices to adapt to Cloud-based architectures. This is recognized as a key step necessary along the roadmap of satellite's eventual integration into a 5G future, with the understanding that Cloud Computing is more than just an expenditure to be handled.

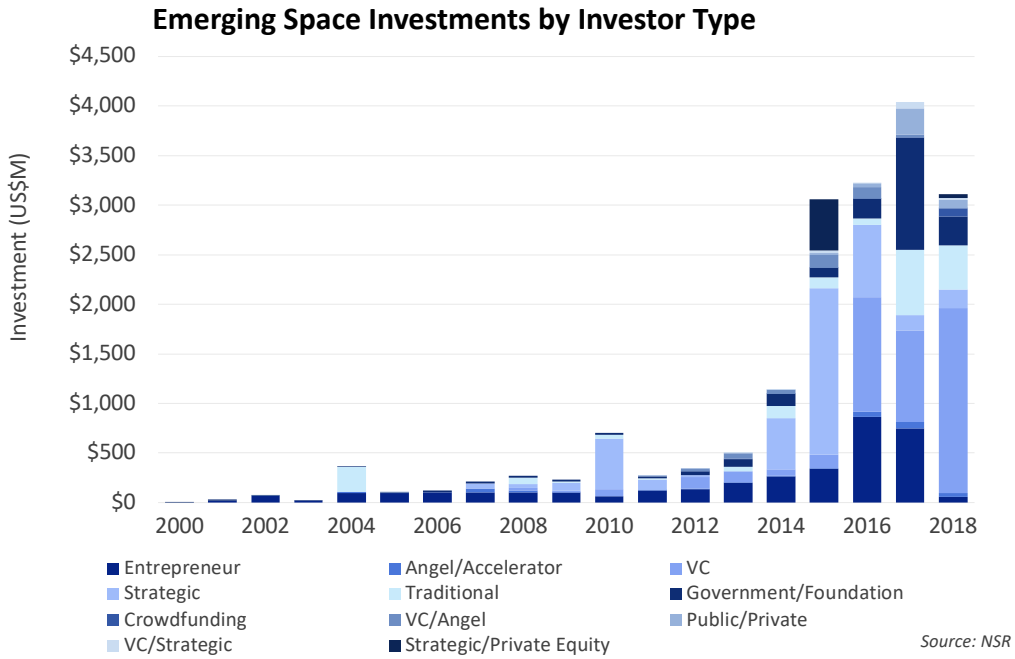
With on-demand measurability and flexibility in spinning up of services, Cloud-based solutions provide a shift from the traditionally CAPEX-heavy investments of satellite ground infrastructure to a reduced OPEX consideration that is flexible and open. In the case of AWS Ground Station, the service is aimed at offering flexible per-minute access to antennas across eight locations for self-service scheduling. This in turn alleviates the customer's need to buy, lease, build or manage a fully owned ground segment. By reducing need for ownership of hardware/software, such solutions also allow satellite players to co-operate with Cloud service providers(CSPs) and deploy their applications/serve their customers with great efficiency.

The traditional CAPEX play of a satellite operator leasing/buying an antenna is giving way to a Cloud-native OPEX play, which is a "pay-per-use" model similar to most Cloud service price offerings. As such, commercial EO satellite operators with a focus on investing capital in the space segment for launch and manufacture, have an additional path to a partially/fully outsourced ground service model that leverages the technological capabilities and financial strategies of the Cloud era. A satellite operator subject to demand uncertainties will find the scheduled contact via the pay-per-minute pricing means spending less capital compared to procuring ground station antennas priced in the millions.

Cloud-Based Ground Services: Key Drivers

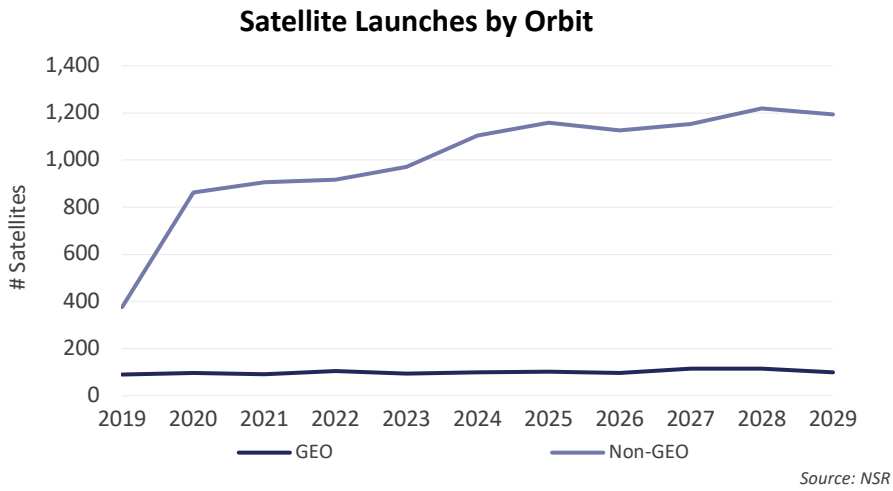
CAPEX Heavy Space Segment: Emergent Small Satellite Players

The satellite industry continues to draw investment interest across a range of risk portfolios, whether of angels and venture capitals, or conservative strategic investors and private equities.



Source: *NSR's Emerging Space Markets Assessment, 2nd Edition*

Emerging players continue to propose newer constellations for Earth Observation, IoT, and Satcom, with platform and analytics solutions to serve customers in the application layer. The relative simplicity of these small satellites impacts the commercial space industry by lowering barriers to entry. Despite this, various functions of satellite operators tend to work in silos and there is a need to seek out lower-cost solutions for integrated business operations, as well as value-added-services (VAS) for end customers. With a majority of investor-focus remaining on the CAPEX heavy space segment, finances will be relatively strained for ground infrastructure development, necessitating the need for a cheaper suite of ground solutions.



Source: *NSR's Global Satellite Manufacturing & Launch Markets, 10th Edition*

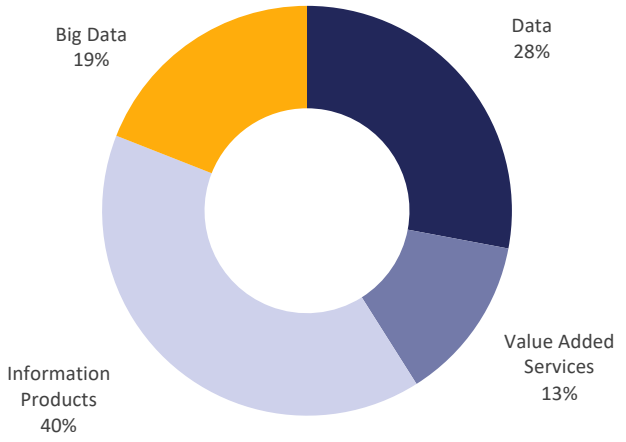
Additionally, multi-satellite launches offer cost reduction and increased opportunities in accessing space, yet another key driver of the satellite market. With more data being transported through/from space, downlinking via direct Cloud integration into adjacent managed services will be a key leverage point going forward.

Rise of the Geospatial Cloud

EO players currently make up the largest share of the data downlink market, with a vast majority of data downlinked onto the Cloud from satellites in the >1,000 kg mass range. NSR's ***Cloud Computing via Satellite*** research report forecasts **486 PB of raw EO data to be downlinked over the next ten years onto Cloud servers**, driven by innovations in EO sensor capabilities that will lead to newer optical, hyperspectral, and Synthetic Aperture Radar (SAR) constellations coming online. However, data supply is only half the story. EO supply continues to outpace demand, and satellite operators are expected to move downstream to leverage this data in multiple ways to meet their bottom line.

This downstream Big Data segment in the Earth Observation industry is the fastest growing sub-segment, wherein satellite operators and analytics providers push to derive deeper actionable insights for their end customers. Despite being a well-established market, the EO industry is on its way towards establishing a clear path for monetization from data supply to customer demand, as many operators strategically shift towards providing analytics via SaaS or PaaS offerings. The adoption of satellite Big Data analytics in the financial services vertical is one of the leading drivers of this downstream market, accelerating its annual growth in comparison to the larger markets of EO Data and Information Products.

Global Satellite-based EO Market Revenues by Segments, 2019-2029



Source: NSR

Source: *NSR's Satellite-Based Earth Observation, 12th Edition*

Alongside the already fragmented downstream big geospatial data market that is expected to consolidate, Cloud-enabled ground systems will be a key enabler in opening up the revenue opportunity here across verticals and regions, as technology rises to meet and innovate on the supply of satellite data.

With expanded and flexible Cloud Computing capacity close to the processing node, insight extraction is also local to end users, thereby also alleviating unnecessary Cloud costs. Satellite operators and downstream players, meanwhile, are shifting away from building the underlying compute infrastructure to deal with the influx of Big Data and actual business problems.

By leveraging the Cloud ecosystem, satellite data analytics becomes easier to deploy for end users, accelerating adoption. The mature service models of established CSPs also enable customers to get involved in app development by offering free access to Cloud and open API, allowing users to develop applications on the platform and expand the addressable market.

On-Cloud services, i.e., the geospatial Cloud, will allow for exactly this kind of optimized service orchestration with customers and a solution such as AWS Ground Station, with its existing inroads into the wider AWS suite of services, will be a key enabler here. The direct access to AWS services such as EC2, S3, SageMaker etc. will enable quicker and cost-effective data processing and analysis before integration into key applications.

Enterprise Digitization and Managed Services

The digitization of enterprise networks is another major trend making its mark across verticals, from energy and maritime to backhaul and (I)IoT satcom, built on top of interoperable solutions.

The decoupling of network hardware from the control plane via SD-WAN, adoption of Big Data insights, the promise of edge computing via remote M2M/IoT deployments, and the impending 5G transformation, together with virtualized network services, are all transformative trends that currently drive an industry-wide shift towards a digitized satcom future.

Cloud solutions will play a key role here as satcom operators and service providers race to keep up with expected increase in the demand for value-added services, either by leveraging direct interconnection programs in partnership with Cloud providers, or by plugging into the wider Cloud ecosystem for deeper systems integration.

Direct Cloud access for satellite operators through a singular platform (AWS) instead of multiple vendors/service providers along the value chain enables customers to deliver data via AWS Ground Station to their region of choice for further processing at a comparatively lower latency.

Cyber-Security Risk Considerations

Enterprise businesses typically manage large IT systems of varying complexities in support of operations. In NSR's view, the market perception of various satellite industry stakeholders, including satellite operators, service providers, and end customers, is that the implications of cyber-risk are key factors in driving decision making. Security is a significant concern to all networked computing systems, Cloud-based or non-Cloud, with potential risks to confidentiality, privacy, and the integrity of data.

With multiple industries undergoing digital transformations, increasing incidences of DDoS, Malware Injection attacks, Keystroke Timing Attacks, etc. offer up a variety of related concerns. For satellite players to address the same, an operator with remote ground stations that are bespoke and isolated will need to build security layers from scratch, incurring associated costs. In addition to tackling issues related to the satellite and space segment, operators will then be required to exert strategic effort in developing a secure ground system, orchestrating various physical and digital interfaces and systems to do so.

On the other hand, infrastructure from Cloud service providers (CSPs) remain some of the more robust access architectures, with advanced monitoring and authentication methods. While vulnerabilities in virtualization can crop up due to the multi-tenancy and ubiquitous network access attributes of the Cloud, mature CSPs provide Service Level Agreements (SLAs) with a robust security policy, providing countermeasures so that satellite players do not have to invest in developing their own secure systems. They provide a suite of solutions ranging from network monitoring and data protection to access management and physical security services, all developed to meet the requirements of the most

security-sensitive organizations. AWS Ground Station, for instance, taps into the broader ecosystem of automated solutions that offer deep integration as part of its AWS Cloud Security offering: this is in line with AWS' shared responsibility model, wherein it manages security "of" the Cloud, including protection of infrastructure that runs all the services, while security "in" the Cloud is managed and configured by the customer, depending on the services selected.

Regardless of the application, a service provider should ideally be able to provide a tailored QoS, in terms of security, that matches customer requirements. A ground station service that can provide a highly scalable, reliable, and secure network backbone can essentially help lower infrastructure costs and improves efficiency for the satellite customer.

Virtualization of the Ground Network

Given the confluence of technology innovations in the space segment, the ground has traditionally seen little change. While the systems have improved consistently, technology has transited a rather silo-focused evolutionary pattern of successive innovations, often driven by the need to achieve increasing performance levels on dedicated and purpose-built proprietary hardware.

There has been a push towards virtualized satellite ground networks, one that can fully leverage dynamically configured space resources and integrate seamlessly with the broader telecom and Cloud ecosystems. Multiple vendors (including players such as Kratos, AMERGINT, etc.) are already making the shift to digital-processing functions to scalable and commodity hardware while investing in modern software capabilities. Exposure of distinct abstraction layers via standardized demarcation points can speed integration with third-party systems and bring new ways to enable service personalization and value-add at the network level.

The Bottom Line

The Cloud paradigm has gradually made its mark in the satellite sector over the past decade, beginning first with the delivery of downstream Cloud-based applications to remote locations via satellite. With newer constellations in non-GEO (HTS and IoT both) expected to smooth latency issues for satcom, fully managed satcom services are on the rise.

The use of a specific CSP delivery model is related to specific customer and application requirements. That said, regardless of application in EO or satcom, Cloud-enabled ground systems will reduce the barrier of entry to market for new startups in the satellite industry. There are clear advantages to be had: a reduction in CAPEX, rapid scalability, ubiquitous access, ease of development and reduced OPEX.

Virtualized ground networks enable the "Cloudification" of the EO and analytics industries, bringing value closer to the end user efficiently. In addition to other new space solutions, such as orbital

storage/compute, the Cloud continues to effectively decouple satellite hardware and software, thus opening up the satellite markets to competition from the wider Big Data ecosystem.

Enterprise digitization and cybersecurity concerns are expected to drive the adoption of fully managed Cloud-based satcom services. The Cloud, and by its virtue, virtualized/dynamic ground system will be essential in the evolution of the traditional EO industry as the non-data market segments grow rapidly.

By opening up the market to a shared infrastructure via a partially/fully outsourced business model, Cloud-based ground station services will bring in business savings alongside improved turnaround times.

Going forward, NSR recommends that constellation operators, satcom vendors and service providers consider building for software-defined networks in space, as virtualization on the ground ramps up. Investing in the development of digitized systems across the satellite value chain will ensure satellite companies are future-proof and can help them leverage existing and upcoming solutions on the Cloud for space applications. Those players with an automated, Cloud-ready approach will be the ones able to scale and provide solutions to the evolving data-intensive satcom and EO markets.

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