NSR White Paper

Cloud Computing via Satellite

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EXECUTIVE SUMMARY

Cloud computing lies at the convergence of multiple technological developments of recent years, as an enabling technology that spans across the satellite value chain. A core component of the satellite big data analytics paradigm, cloud computing is essential in deriving valuable business insights relevant to multiple stakeholders in the industry from the large variety of data generated.

As big data continues to grow (a $3B opportunity by the end of the decade, according to NSR's *Big Data Analytics via Satellite, 2nd Edition* report), there is a rising need to better optimize the storage, delivery, and analysis of data. Built on top of the physical distribution of hardware and the virtualization of services, satellite-based cloud computing comes into play once an application/service involves enough co-ordination of a distributed array of physical infrastructure to the point that the source/location of data is no longer relevant. NSR foresees the need of cloud computing for the satellite industry spanning different customer verticals: ranging from the land/maritime transportation and government/military sectors, to the energy and enterprise markets.

Increased investment in the satellite sector is spurring a larger number of services and products driven by a greater supply of satellite data. The geospatial cloud is more real now than ever, and digitization across satellite customer verticals continues to drive demand for deeper insights.

Cybersecurity concerns are prompting more talk on cloud computing in the satellite industry, with a market opportunity that spans across Earth Observation (EO), Machine-to-Machine (M2M)/Internet-of-Things (IoT) satcom, network operations and more. Inherent advantages of the cloud notwithstanding, overcoming the challenges that come with shifting to a cloud-based approach will be crucial for satellite businesses to remain competitive and grow their business.

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Addressing the Challenges of Big Data

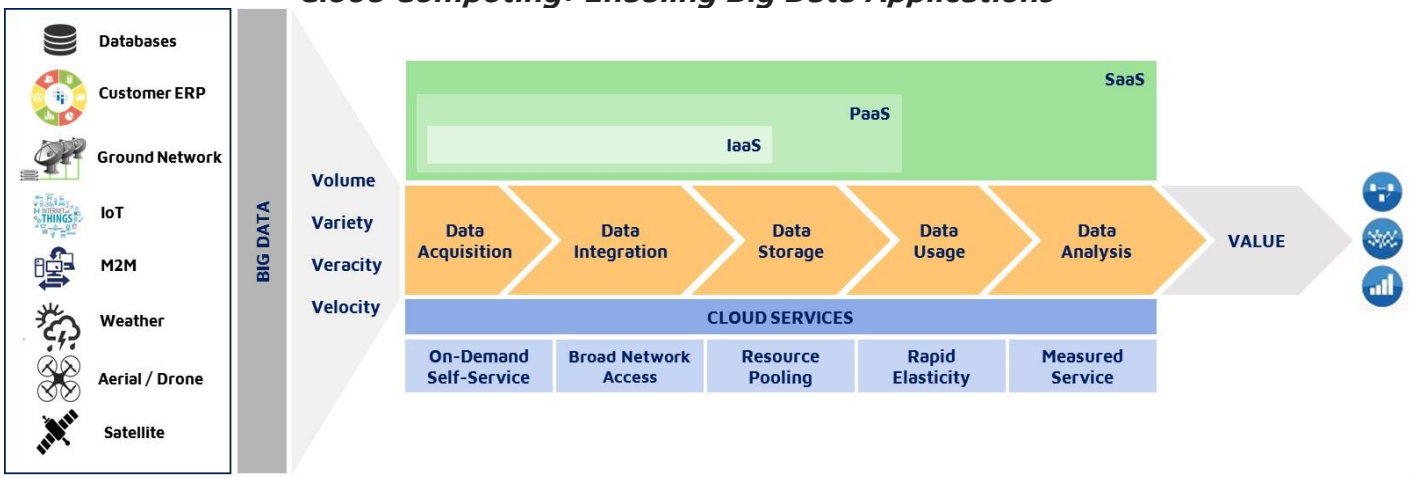
Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

- **Definition of Cloud Computing, NIST [2011]**

The big data value chain describes the information flow within a big data system as a series of steps needed to generate value and useful insights from data: key high-level activities here being data acquisition, data integration, data storage, data usage and data analysis.

Big geospatial data, for instance, poses many challenges during this lifecycle. It is here that cloud computing can transform a business. It can tackle the 4V Challenges (Volume, Variety, Velocity, Veracity) of big data by leveraging its key attributes; i.e., on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service, to arrive at tangible value for the end-user.

Cloud Computing: Enabling Big Data Applications



Source: NSR

The large nature of real-time spatiotemporal data can only be managed in a scalable, distributed, and adaptive network environment. By facilitating on-demand reliable Virtual Machines (VMs) as required and automatically deploying the necessary big data platforms, cloud computing offers fast storage, access, and indexing of, rapidly acquired data. On-demand compute power can be allocated by auto-scaling, depending on the volume of data. The capacity of broad network access can serve the processing of a larger variety of ingested data, by leveraging advanced scalability functions. Additionally, data integration can be performed with minimal

effort to improve accuracy of the model, with an entire process being isolated and preserved in a VM image, reducing potential errors.

The three service delivery models of a Cloud Service Provider (CSP), (Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS), each come with their own pros and cons. However, the advantages of incorporating the cloud into satellite business, either earth observation or satellite network operations, is clear: a reduction of upfront capital expenditures, as well as operational costs, rapid scalability, ease of development, unlimited storage, and ubiquitous accessibility.

Following the manipulation of data throughout its lifecycle, from acquisition to insight, the value chain can be analyzed according to its specific components. With data of a remote location being captured in the 0th layer, i.e., via earth observation or communications with remote terminals, the data manufacturers use satellites (1st layer) to generate and/or transmit it down to ground infrastructure terminals (2nd layer). Cloud architecture then provides a virtual platform to form a data resource pool. After a series of storage, processing and distribution in the cloud (3rd layer), valuable data-driven insights are extracted and delivered to the end-user via 'big data applications', which forms the 4th and final layer of the value chain.

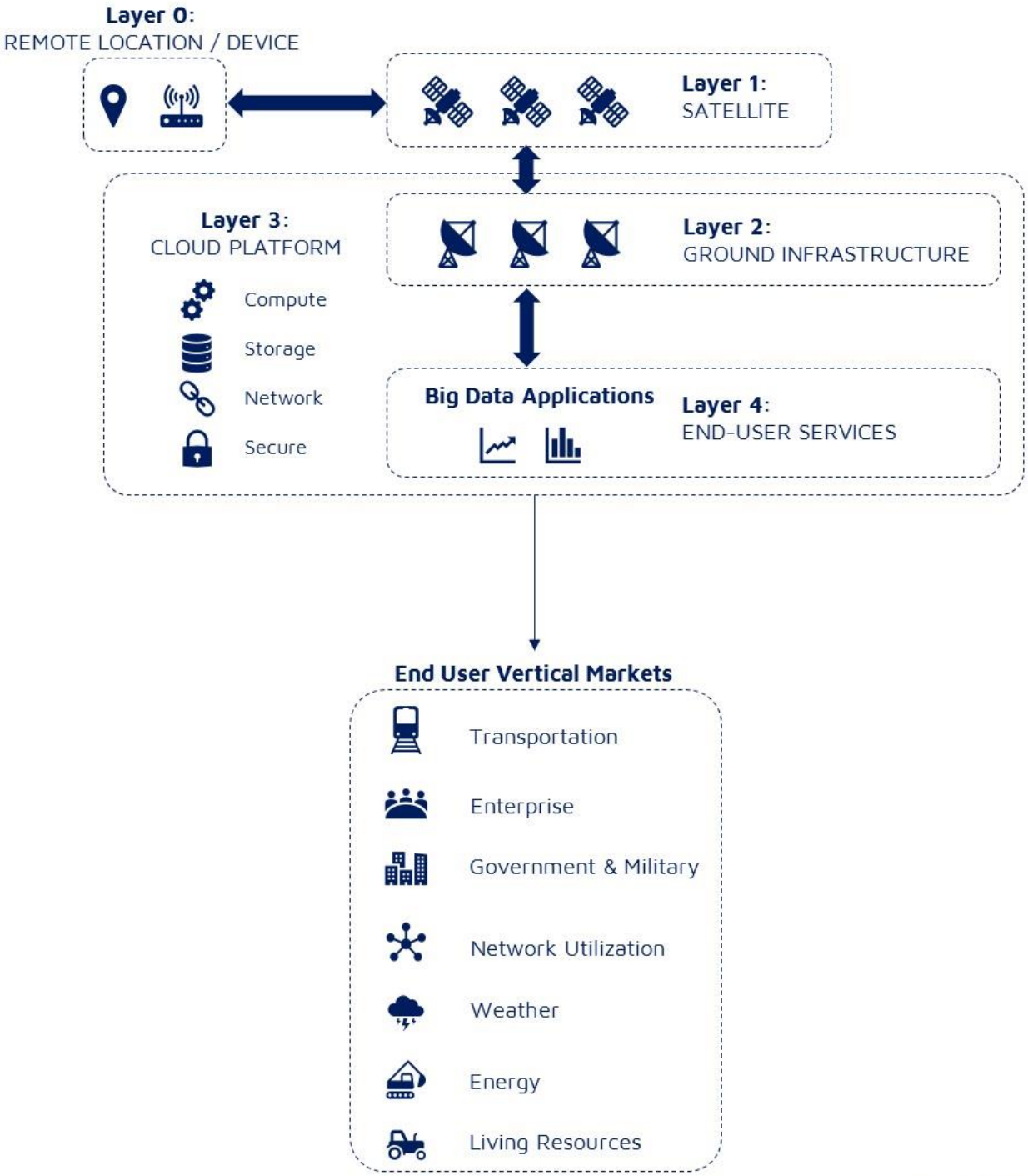
The exhibit below spells out in detail the function of each of these layers as used in EO, M2M/IoT and satellite operations.

Satellite-based Cloud Computing Value Chain

Layer 0	Remote Location / Terminal	Images captured via in-space sensors for EO, terminals transmit signals to space for satcom
Layer 1	Satellite	The satellite operators act as data manufacturers/providers. • EO: Satellite sensors produce images • M2M/IoT/AIS: Data from remote terminals is gathered and reflected. • Satellite operations: Telemetry, Tracking and Command (TT&C) data is transmitted down to the ground segment.
Layer 2	Ground Infrastructure	Data storage, processing and delivery. This layer usually consists of ground stations and servers.
Layer 3	Cloud Service	CSP provides a cloud platform/architecture to be deployed as a public, private, hybrid or community cloud model as applicable
Layer 4	End-User Application	Business functions / companies that act as customers of the CSP productize the data and deliver VAS and expertise to end-users across different verticals.

Source: NSR

Satellite-based Cloud Computing Value Chain



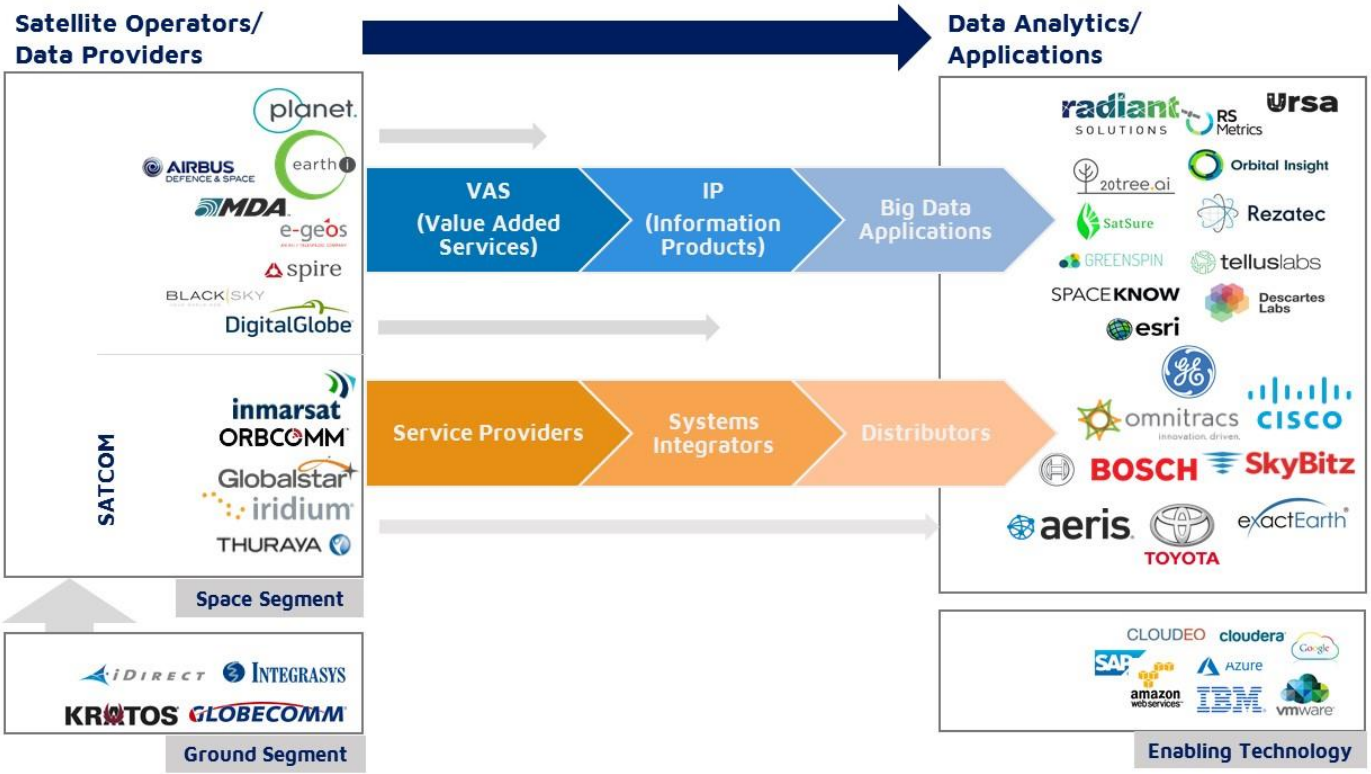
Source: NSR

An Industry in Transition

The satellite big data industry is at an inflection point. NSR's Big Data Analytics via Satellite, 2nd Edition report forecasts the global revenue opportunity, from satellite-based big data analytics alone, to reach close to $3B by 2027. The development and application of multiple technologies will play an important role in the value chain of the space industry and driving this change.

Upon observation, a few key trends can be delineated as widely impacting the market factors driving technological adoption in the satellite industry.

Satellite Big Data Industry Actors: Value Chain



Source: NSR

- **Emerging Space Players Growth**

  Investment in the satellite industry, as a whole, is seeing growth recently, continuing to draw the attention of VCs, as well as more conservative investment groups (national governments, private equity).

  Driven by technological developments that touch everything from manufacturing processes to business analytics; most emerging small satellite players have proposed constellations for EO, IoT, and satcom, with analytics solutions to serve customers in the application layer. With the increased supply to meet demand

driven by digitization in customer verticals, satellite operators must seek out lower-cost solutions for business operations and value-added-services (VAS) to improve their marginal benefits. On-demand, flexible, and reliable cloud services then emerge as a major cost reducer for satellite players.

A parallel growth is seen in the increasing number of launch opportunities for satellites. The technology of packaging more satellites in one launch vehicle offers increased opportunities and cost reduction in accessing space, a key factor that will drive the satellite market. With more data being generated in/from space, cloud computing will become an integral part of improving operational efficiencies. The standardization of production lines and small satellite constellations are key drivers here, fueling an ecosystem that supports the small satellite movement, from manufacturers to launch service and tailored propulsion systems providers.

- **The Geospatial Cloud for Satellite Big Data Analytics**

  With the growing supply of EO satellites expected to enter the market, the traditional EO industry has evolved to include big data analytics, the fastest growing sub-segment, as the solution to extract more value from a growing repository of data. For instance, Planet, a satellite operator and provider of EO data, has historically focused on imaging the Earth and providing imagery data, storing them on myriad cloud services. Getting closer to their goal of imaging the entire Earth, the company has made a strategic shift towards providing analytics solutions. This further integrates end-user applications within their existing platforms, enabling users to answer questions of their own.

  The expanded computing capacity of the cloud has brought many new results. Information and insight extraction for end-customers becomes much less expensive, and the focus moves away from building the underlying infrastructure to dealing with the influx of big data and solving actual business problems. By leveraging the power of the cloud ecosystem, satellite data analytics becomes easier to deploy for end users, thereby accelerating adoption. The cloud platform provided by large companies with mature service models, enables customers to get involved in app development by offering free access to cloud and open APIs, thus allowing users to develop applications on the platform.

- **Digitization and the Growth of M2M/IoT**

  Another major technology trend underway is the IoT revolution, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies. The combination of IoT and satellite-based cloud computing can compensate for the technical limitations of IoT in terms of data collection, storage, and processing.

Much of the most economically critical IoT activity is going to take place at the edge of the network, and that is territory the satellite industry knows well. The number of connections is not in the billions. Growth is not going to take your breath away. But the value of extending IoT beyond the network's edge is real, as is the customer's return on investment.

- **Robert Bell, WTA**

Digitalization is fast taking over many historically intransigent industries. Many companies adopt transformative technologies such as IoT, while also giving way for cultural adjustments within the organizations. Rio Tinto, a leading mining corporation, has developmental plans for the Koodaideri iron ore mine, which are expected to make it one of the most technologically advanced mines in the world. This is but one example of a variety of industries embracing change and shifting to digital. While such customers leverage the power of automation, satellite communications providers must keep up with the expected increase in demand for connectivity, and cloud computing plays a crucial role here. SES Networks is one player that has moved in the right direction. By collaborating with IBM, SES is ensuring that customers with limited connectivity options, in remote regions can easily deploy their applications and solutions onto the cloud, taking advantage of its global network coverage.

- **Security Concerns**

The large nature of operational technologies, and IT systems used to manage enterprise businesses, offers up a variety of cyber security concerns. The 2017 Petya ransomware attack on Maersk, the Danish transport/logistics conglomerate, was a clear call for many industries to address the rising concerns around cyber-attacks.

Security remains one of the biggest threats to all networked computing systems, with potential risks to the confidentiality, privacy and integrity of data. In case of an attack, a cloud-based-infrastructure faces more consequences as opposed to a non-cloud infrastructure, making detection, prevention and response to cyber-attacks even more challenging. Increased incidences of DDoS, Keystroke Timing Attacks, Cloud Malware Injection attacks, etc. are exacerbated by exploitation of the multi-tenancy and ubiquitous network access attributes of the cloud, and by taking advantage of vulnerabilities in virtualization.

However, cloud platforms are slowly shifting to more robust access architectures, authentication methods, and advanced monitoring techniques. Mature CSPs offer Service Level Agreements (SLAs) with a robust security policy, offering

countermeasures against potential attacks so satellite companies do not have to waste time and money developing their own. With a Quality of Service (QoS) that can be tailored to each customer, CSPs help lower infrastructure costs and improve efficiency.

Market Opportunity for Satellite

NSR identifies four key market segments where the impact of cloud computing is seen in the satellite industry, with some already underway.

- **EO**

  Traditionally driven by imagery/data and VAS, the information products and big data analytics segments are expected to drive the Earth Observation market in the future. With an oversupply of data resulting from newer constellations in orbit, pricing of data is on a steady decline. From data to insights, the market is responding to the demand for business insights by moving down the EO value chain. The growing ecosystem of distributed networks and visualization of big data applications will see a prime fit for cloud computing.

- **M2M/IoT**

  MSS M2M IoT connectivity, alongside IoT small satellite constellations, will continue to drive this segment. With more terminals coming online, satellite operators are expected to offer seamless and reliable networking and computing services to their customers. As more data is acquired, the demand for analytics is expected to increase in a variety of use cases. And satellite players are only beginning to move across the value chain to meet this demand: Iridium CloudConnect, a result of the collaboration between Iridium Communications, a global voice/data satcom network provider, and Amazon Web Services, is one such integrated satellite-based cloud computing solution, expected to provide global coverage for IoT applications.

- **Satellite Network Operations**

  Satellite network operations is one of the more established applications of cloud computing in the satellite industry. With the promise of improved flexibility and efficiency, ground stations are linked with the Internet, leveraging the computing, storage, and network capabilities of the cloud to deliver appropriate products and services to their end-users. If satellite players are intent on providing cost-effective services, taking advantage of established experts in the big data ecosystem will become essential. iDirect, a leader in IP-based satcom solutions, uses a data analytics platform provided by industry leaders in cloud data integration solutions to optimize satellite performance.

- **Satellite-based Cloud Storage**

  Still a nascent segment, the cloud here is integrated into the satellite value chain to provide in-space storage services. Partnering with CSPs looking to provide greater security and reliability to end-users by providing a secure, in-space storage infrastructure, is one area where satellite actors can leverage future cloud infrastructure. The patented Data-Security-as-a-Service (DSaaS) by Cloud Constellation's Spacebelt, for example, circumvents the inherent vulnerabilities of terrestrial networks altogether by providing an isolated storage service with space-based assets.

Technology Ratchets in the Satellite Industry

Technology begets more technology, and the cloud comes with the promise of transforming every business it touches. With wide-ranging impact across the satellite industry, the adoption of cloud computing has multiple benefits to an organization, creating additional business opportunities. It will act as an enabler, reducing the barrier of entry to market for small companies and new start-ups in the satellite industry.

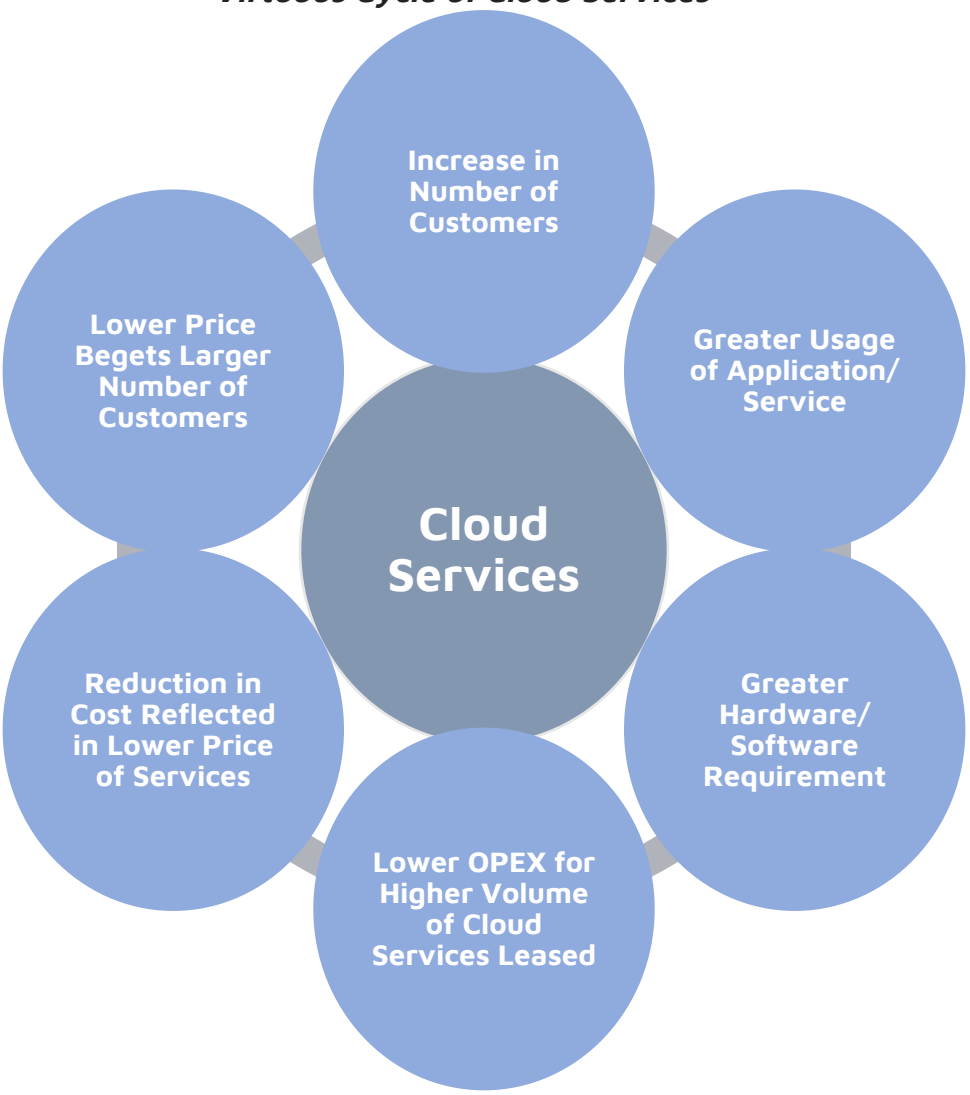
By being flexible and providing on-demand measurability, it offers a shift from CAPEX heavy investments to reduced operating costs. By reducing the need for ownership of hardware/software, it allows small businesses to co-operate with CSPs and deploy their applications much faster. Additionally, the cloud allows larger enterprises to expand their businesses and gain better insight into their market. Traditional hardware and software providers that based their architectures on the physical network layer are also beginning to adapt to the cloud, thereby promoting a transformation of architecture design; bringing software design closer to user needs in the application layer.

For globally diversified corporations with facilities and assets distributed geographically (including in remote regions), satellite communications is sometimes the only connectivity option available. The large, dispersed nature of such businesses demands the adoption of a cloud-first approach. Application performance and reliability need to be ensured across the organization, regardless of location. A tighter integration with the cloud becomes essential for satellite and ground teleport operators whose revenue streams depend on such customers. Furthermore, partnerships with the right service providers is paramount to ensure that bandwidth and latency requirements are met effectively.

Satellite-based cloud computing provides opportunities not only to players in the traditional satellite industry, such as Launch Service Providers (LSPs), small satellite

manufacturers, and ground station operators, but also to players from other industry sectors such as platform providers, application developers, and application integrators. Through collaboration and cooperation, a more effective distribution and utilization of resources will pave the way for a broader market.

Virtuous Cycle of Cloud Services



Source: NSR

Many Challenges Ahead

It is well established that by providing highly scalable resources available on demand and without service interruption, the advantages of the cloud are many. It saves cost of infrastructure, management, as well as energy, while at the same time enabling an organization to be more agile with deploying IT resources and applications. However, the adoption of cloud computing in the satellite industry is picking up only now, with challenges that remain to be overcome.

- **Understanding Customer Expectations**

  The satellite value chain is continuously evolving with newer technologies being brought into the mix, thereby generating a variety of customer needs. The right understanding of these needs will be crucial in being able to match them with appropriate (cloud-hosted) services/applications.

- **Slow Growth of the M2M/IoT Market**

  While the overall market for M2M/IoT and EO is sizable, the share for the satellite sector remains to be seen. The frugal nature of customers in the slowly growing M2M/IoT markets with low margins can reduce the opportunity for a specific ancillary cloud-based business to develop.

- **Security Risks in the Cloud Environment**

  The impact of cyber-attacks has increased greatly in a cloud-based ecosystem. The growth of cloud-computing is a double-edged sword; while bringing in newer business opportunities enabled by its inherent advantages, the increased network complexity will also make detection and prevention of security breaches that much more difficult. Security costs for industry actors or CSPs will increase.

- **Internalization of Cloud Technologies**

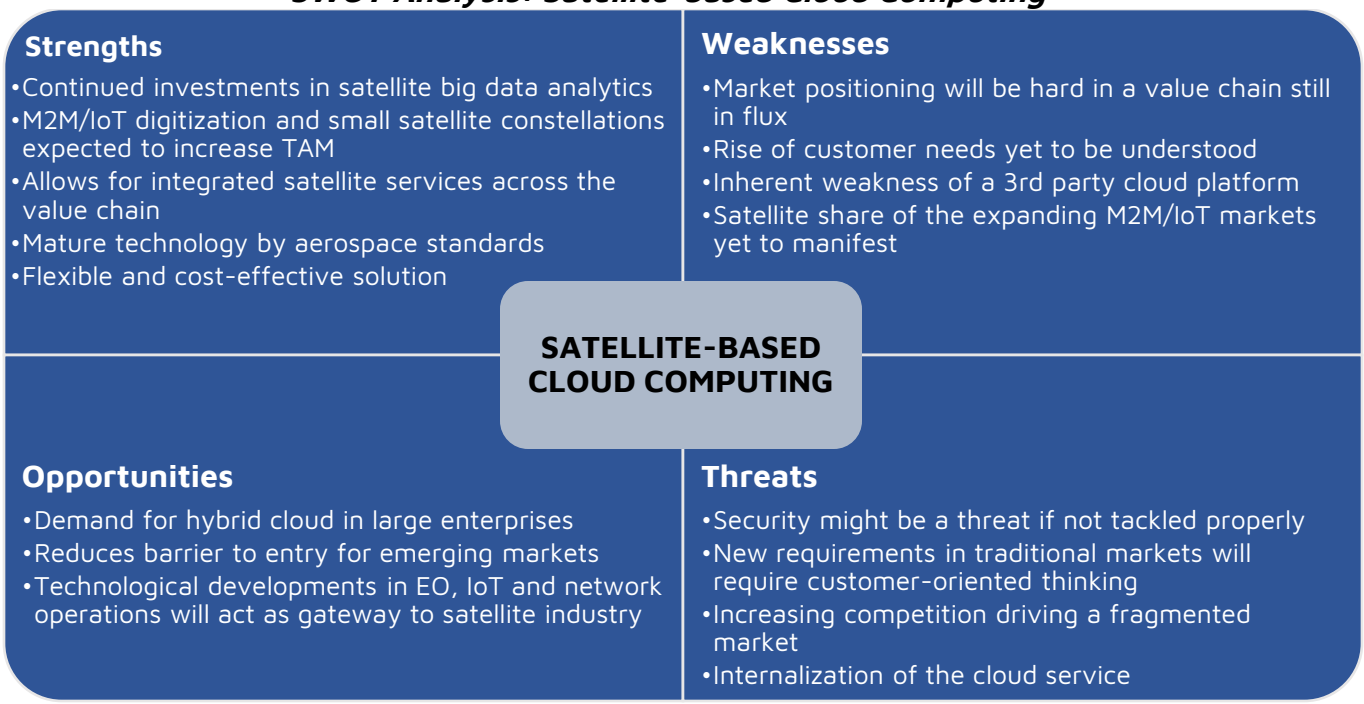
  When an organization develops/uses cloud computing to aid its business operations, it reduces the CAPEX required to deploy customer applications. However, the investment that goes into accessing the cloud also runs the risk of non-commercialization; i.e., bringing no ROI into the mix. Finding the right channel to monetize and externalize its cloud capabilities will be key in remaining competitive. Early on, DigitalGlobe, a leading EO data and geospatial vendor, developed technologies to help sort through massive archives of imagery to sell in the traditional way. However, it was not until the EarthWatch portal was developed, that these cloud-computing technologies were being monetized.

Bringing together the market trends, opportunities, advantages and challenges of satellite-based cloud computing, delineated in the preceding sections, a SWOT

analysis reveals, despite the inherent threats and challenges adoption might face, the market opportunity for cloud computing in the industry is ripe with potential, driven by continued investments and digitization trends.

Through value-added services, satellite-based cloud computing is expected to generate more revenue. Newer technologies will further refine the value chain, and enterprises will continue to strive for competitive advantages by way of alliances, mergers and acquisitions.

SWOT Analysis: Satellite-based Cloud Computing



Source : NSR

The Bottom Line

As mobility amplifies and location becomes more significant for the satellite world, the cloud will continue to grow globally. CSPs will succeed where they can provide the platform required to build better applications and improved monitoring capabilities by adopting newer technological developments in AI and big data. Cloud computing in the satellite industry is more than just an expenditure to be handled. It plays a critical role that can help a satellite player remain competitive.

In the early stages of satellite big data, cloud computing is still fragmented today. The emergence of different application scenarios such as in EO, IoT, Space Situational Awareness (SSA), etc., technologies and approaches will continue to merge with each other. The market will evolve, with enterprises going through partnerships, mergers, and acquisitions, to strive for resources and a competitive advantage, as well as moving across the value chain.

Satellites offer visibility and connectivity, into and across the global economy via imagery and data/media communications whether for cruise ships, urban infrastructure, mine establishments, farms or more. By integrating multiple such services onto well-defined platforms, the satellite industry is well-poised to leverage the power of cloud computing to offer solutions that address customer needs and solve real business problems.

About NSR

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