

3G AND 4G/LTE FOR REMOTE, RURAL, AND UNDERSERVED AREAS

SES Networks' O3b MEO system delivers 3G and 4G/LTE services with unmatched reliability, performance and reach

With the advent of 2G network architectures in the early 1990's, Mobile Network Operators (MNOS) for the first time introduced digital data to subscriber handsets. But throughputs on 2G range from 9.6 -200Kbps, limiting capabilities. When 3G was introduced, throughputs increased to 2-10+Mbps enabling more robust applications and the introduction of "App Stores," creating an improved experience for subscribers, as well as increased revenue opportunities for MNOs. Finally, 4G, synonymous with LTE (Long Term Evolution), was delivered, providing the most advanced mobile communications architecture available. 4G/LTE provides efficient, fully IP-based handling of both data and voice traffic, thus lowering costs for operators, reducing data latency, increasing data throughputs, and enabling a host of compelling new applications for subscribers.

Without question, 4G/LTE is the best network architecture available to MNOs for lowering costs and raising revenues. SES Networks' O3b MEO satellite network is the only one capable of supporting 4G/LTE deployment in hard to reach places, and it does so affordably, eliminating the uncertainty of success for MNOs. Because of spectrum cost and availability in some markets, 4G/LTE is not an option for every operator. For these MNOs. SES Networks enables implementation of an ideal 3G setup, configured as a terrestrial network, but without the need for complicated and expensive special software that is typically required for traditional satellite links. Later if a migration to 4G/LTE is expected. SES Networks again assists to ensure a seamless transition.



EASY ACCESS TO ADVANCED MOBILE SERVICES

SERVICES SUBSCRIBERS WANT, EVEN IN REMOTE AREAS

Advanced mobile data services have had a dramatically faster adoption rate than 2G, and people in remote or inaccessible areas want these same advanced services. beams can also easily support fiber build-outs and be quickly redeployed to a new coverage area as needed.

The assurance of reduced costs, together with simultaneous increases in data usage, ARPU and overall subscribers, SES Networks has already assisted MNOs around the world remove the uncertainty associated S1 is a single interface between LTE RAN and the EPC, performing the following functions:

- S1-UP (User Plane) is responsible for delivering user data between the eNodeB and the S-GW
- S1-CP (Control Plane) is responsible for delivering signalling protocols between the eNodeB and the MME. The S1-CP is extremely

\downarrow Cost/MB + \uparrow DATA/Subscriber + \uparrow Subscribers = Rural 3G or 4G/LTE Business Case

Terrestrial fiber is an ideal solution to connect subscribers to an MNOs network in densely populated and unchallenging geographies. But for regions that are difficult to access — even if there is a sizeable base of customers — laying fiber is too expensive to close the business case. Satellite is the only option available to reach these regions, but traditional satellites can't provide the throughput, low latency and performance required for 3G or 4G/LTE services.

SES Networks' O3b MEO system offers the most effective method for connecting to locations that cost too much when using fiber. The cost per Mbps is typically 30% lower than traditional satellites. Newer generation networks — like LTE — also have a lower cost/MB by using one IP network for voice and data and fewer hierarchical management components in a flat design.

Better performance of 4G/LTE over a high performance O3b link results in a better user experience, increasing usage per subscriber.

The improved user experience is also critical in attracting new subscribers, and in a competitive environment it is often the first mover to a new technology that takes market share The O3b MEO system solutions can be deployed much faster — days instead of months — when compared to fiber infrastructure. Steerable MEO with deploying 3G or 4G/LTE to remote and hard to reach populations.

ENABLING AFFORDABLE 3G AND 4G/LTE ANYWHERE

Whether there are mountains, jungles, rivers, oceans or sheer distance, O3b MEO-enabled solutions are the perfect vehicle to overcome any difficult geographic barrier standing in the way of delivering high-performance mobile data to subscribers. Even potential political instability or armed conflict, which make it impossible to protect fiber lines, are easily circumvented by SES Networks' state-of-the-art carrier-grade global network. Additionally, the O3b MEO system provides almost unlimited scalability, and is re-deployable, so as an MNO network evolves, data services can be extended at the edge of coverage, or wherever it is needed on-demand.

DELIVERING MOBILE BROADBAND (MBB) OVER SATELLITES

4G/LTE specifications include a minimum requirement for S1 interface workability, including a Packet Delay Budget (PDB) of approximately 200ms round-trip time (RTT) and Packet Delay Variation/Jitter for NTP traffic= ~ 5-10ms. latency-sensitive, and the entire link will fail if the latency is too high.

GEO BACKHAUL IS NOT ENOUGH

GEO satellites can provide backhaul for 2G data because the latency and jitter standards are less stringent However, with a RTT latency of over 550ms, GEO simply cannot adequately handle 4G/LTE traffic. Even the 3G data experience over GEO is quite poor due to the lower number of data packets that can make it through the network, even if the throughput is increased, relative to O3b and fiber. The result is slow web browsing, video buffering and performance problems with cloud-based applications.

DELIVERING 4G/LTE ANYWHERE

The extremely low latency O3b MEO system, with less than 150ms RTT, meets current 4G/LTE specifications. The performance of O3b MEO connection is comparable to that of long-haul fiber, providing superb internet connectivity and user experience in even the most difficult to reach locations.





Direct benefits to:

- Cloud-based Applications
- Voice over IP (VoIP)
- Live Mobile Video
- Mobile Gaming
- Augmented Reality

Figure 1

SES Networks' Multi-orbit, Multi-band Satellite System

When an MNO wants to implement a high-performance data service, things to consider include:

- Latency becomes a show stopper to support S1 interface (eNB – MME EPC)
- 4G/LTE has a required packet delay budget not to exceed 200ms RTT, O3b MEO RTT is <150ms, while GEO RTT is about 650ms which causes extreme degradation in throughput
- RAN vendors do not support backhaul timers (S1) with the high latency of GEO systems
- Low latency, such as provided by SES Networks, allows LTE S1 to achieve similar throughput comparable to terrestrial and MOS and vMOS performance for voice and video.

 O3b MEO is the ideal satellite network for supporting RAN sharing mocble model is a shared infrastructure that can aggregate multiple MNOs' traffic using a single high capacity transmission site.

OPPORTUNITIES FOR INCREASED ARPU

3G and 4G/LTE provides the mobile data experience subscribers want, and SES Networks enables MNOs to deliver it at an affordable price. As data network quality and performance improves, operators will see higher throughput and usage. LTE subscribers are extremely heavy data consumers, driving data growth for the MNO. With data-heavy applications such as over-the-top (OTT) audio and video, the operator can count on their 4G/LTE base to drive exponential increases in data usage, which will increase ARPU and overall revenues.

Business from enterprise customers becomes another opportunity for operators to increase data usage and revenues via mobile data. Real-time sharing of large files, streaming media, video conferencing, near-immediate delivery of time-sensitive data for real-time interactions or transactions are typical enterprise applications available via the cloud, leading to better utilisation of existing bandwidth and additional on-demand bandwidth made available through a 3G or 4G/LTE MBB network.

New applications supported by scalable, low latency connectivity, can be used to create new revenue opportunities that include:





Real-time Gaming



REDUCE CHURN, INCREASE MARKET SHARE

Subscribers who consistently have a superior Quality of Experience (QoE) when consuming digital content or accessing cloud-based applications, will be more satisfied and loyal. As a result, MNOs using a SES Networks solution see higher bandwidth usage and lower customer churn rates. The improved network quality and performance delivered through the O3b MEO system gives MNOs a positive boost in their reputation.

MNOs that are first to market with services delivered over O3b MEO can quickly yield an increase in market share. SES Networks works closely with MNOs to make the market aware of new network capabilities, creating a strategic advantage over operators only offering older generations of connectivity with limited or no data services.

THE MARKET OPPORTUNITY

At the end of 2013, the GSMA stated in their "Global LTE network forecasts and assumptions: 2013-17" report that 4G/LTE users were, on average, using 1.5GB per month. That's nearly double the data consumed by subscribers on all other network types.

SES Networks has helped MNOs worldwide to evolve their 2G. 3G. and 4G/LTE networks to deliver more and better mobile internet, content and application services to their subscribers. The results have been incredible - Orange is using a SES Networks solution to backhaul 3G mobile services in the Democratic Republic of the Congo (DRC). Since moving to the SES Networks solution, Orange has seen data growth of 70% year over year. Since launching service over the O3b MEO system on Christmas Island. CiiA has seen a 300% increase in data usage. Similarly, Digicel Samoa has experienced a greater than 300% increase in data usage when moving to 3G, and has deployed LTE. And Warid LTE in Pakistan, using 4G/LTE, has seen data usage increase 6x over MBB in just one year.

SERVICE REVENUE FOR 3G AND 4G/LTE

4G/LTE revenue is expected to increase by 35% in 2016 to \$426 billion (\$381 billion). Strategy Analytics (SA) research published in June 2016 predicts that 4G/LTE revenue growth will be offset by a 21 percent decline in 2G service revenue and 19 per cent decline in 3G revenue in 2016.

Figure 2 below shows MNOs service revenues by generation of mobile technology.



MAKING THE JUMP FROM 2G TO 4G/LTE

THE PROMISE OF 4G/LTE

4G/LTE is the culmination of decades of mobile innovations and evolution, and is a flattened, ultra-streamlined, fully IP-based network architecture. The flat architecture efficiently handles both voice and data transport combined into a single network with no hierarchy, allowing direct tunnelling between remote entities to the Evolved Packet Core (EPC) network. 4G/LTE has higher standards and substantial improvements on previous generations in several respects:

- Higher throughput increasing the speed of data transfer
- Lower latency providing faster response times from the network
- Improved spectrum efficiency which increases overall network capacity

The high throughputs and low latency of the O3b MEO system are comparable to terrestrial fiber, enabling affordable 4G/LTE implementation for most remote and difficult to reach locations. This provides an opportunity for MNOs to move from a 2G infrastructure straight to 4G/LTE.

4G is a far more cost-effective architecture for networks than previous generations. Its Quality of Service (QoS) and Class of Service (CoS) management capabilities mean that applications, such as web surfing, voice & video calls, and HD video streaming, can be assigned network performance characteristics, providing a consistent and high-quality user experience.

THE BENEFITS OF 4G/LTE

 All network elements are IP-based and the network architecture is flat, from the remote site across the core network, decreasing Total Cost of Ownership (TCO) and end-to-end latency. This results in improved accessibility and QoE; reduced power consumption for a greener more sustainable solution; an order of magnitude increase in capacity and flexibility to manage growth; all integrated seamlessly with the existing network.

- Increased Total Value of Ownership (TVO), because both CAPEX and OPEX costs are driven down while revenue opportunities are significantly increased.
- LTE's various innovations enable data delivery to end-users at less than half the cost per bit of existing GSM and 3G technologies, easily making the case for 4G/LTE affordability and capabilities over the O3b MEO satellite network.
- The 4G/LTE radio interface has the flexibility to operate in both Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD) modes, making the use of carrier aggregation to bond together channels of different widths and frequency bands to enable very high data throughput. Uplink and downlink capacity ratios can also be modified dynamically as needed, providing high flexibility to the MNO.
- The LTE-A version allows download speeds up to 1Gbps by bonding together 60 MHz of spectrum in different frequency bands using 256 QAM modulation and 4x4 MIMO antenna systems (meaning more antennas are used together to provide higher throughput).
- A strong advantage for MNOs deploying LTE-based satellite backhaul is the ability to address new markets that may not have previously been profitable.

4G/LTE IS FUTURE-PROOF

While 3G technology is a fundamentally more efficient and robust network architecture than 2G or 2.5G, there are limitations and inefficiencies compared with 4G/LTE. Equipment is available that will handle traffic from any flavour of network-2G, 3G & 4G/LTE—so investments will still pay dividends as your subscriber base transitions fully to 4G/LTE over time. But the efficiencies and improved performance of 4G/LTE, combined with the flexible delivery capabilities of the O3b MEO satellite network makes it worthwhile to consider accelerating plans to deploy, if at all possible.

SES Networks can assist MNOs in deploying 4G/LTE, future-proofing the network:

- The O3b MEO network is fully agnostic, handling 2G, 3G, and 4G/LTE for both backhaul and core network deployments
- Individual technology and/or mixture of multi RAN vendors over a single terminal
- Carry separate voice and MBB traffic independently

SATELLITE-ENABLED MBB SUCCESSES

BETTER MOBILE BACKHAUL

Until now, satellite backhaul technology evolution has not matched the increasing performance needs of mobile networks. GEO satellite systems cannot deliver the low latency required for a multitude of modern applications—because of the fixed speed of light and the distance from Earth—and the bottleneck on throughput resulting from the GEO latency creates further complications for mobile network needs today, and heading into the future.

Data rate requirements have increased as mobile technology evolved from 2G to 3G to 4G/LTE, and latency requirements decreased at the same time. The reason is that as the data rate increases, latency is what limits the performance of the link. Figure 2 shows how the end-to-end latency requirements have steadily become more stringent as mobile technology has evolved.

When looking at the latency of GEO, it's clear that having low latency isn't required for 2G services. With 3G backhaul however, the satellite latency is the limiting factor and dominates the overall performance. The O3b MEO system's lower latency allows operators to maximise the performance benefits of their investment in 3G and 4G/LTE technologies.

Proven in Lab Test Certifications

The low latency of MEO was a key part of Huawei's evaluation of SES Networks as it ran through a full suite of 2G, 3G, 4G/LTE and eLTE testing, all of which showed O3b MEO-enabled services performed on par with terrestrial fiber for every tested application. A key finding of the tests was the ability to use the standard software load with O3b MEO, while traditional GEO satellites required the creation of a special software configuration with extended timers to account for the higher delay,



Figure 2 End-to-End Latency by Technology

increasing costs and complexities.

ZTE testing involved mobile to mobile voice calls over 2G and 3G, high speed data download/upload over 3G-HSPA, LTE and mobile video services. The standard terrestrial configuration was used in the mobile network and no special configuration was required for full data throughputs and excellent voice quality.

Proven in Live Field Trials and Pilots

O3b conducted field trials and pilots with a number of Tier 1 mobile operators:

CUSTOMER	ТҮРЕ
Claro Brazil	3G Nokia lub
Oceus – Ericsson	tactic LTE core network SGI
Ufone	2-3G Huawei (Abis, lub)
Telenor Pakistan	3G Huawei (lub)
Warid LTE	LTE Ericsson (commercial) – S1
Telenor Myanmar	(Huawei 3G lub (commercial)

Some notable results from these field trials and pilots include:

• A field trial with Claro Brazil showed a consistent, stable link for all planned scenarios, and all indicators related to the satellite lub link were achieved. SES Networks' O3b MEO performance exceeded the Key Performance Indicators (KPIs) agreed upon with Claro for such service, including: Packet Loss <1,0%, Availability >99%, Latency <200ms, CQI CS >97.0%, CQI PS >95.5%, CS Drop <1%, PS Drop <1,5%.

- A field trial with Ufone showed link uptime of 100%, RTT latency of 149ms, packet loss of .0277%, and jitter of 20ms. Throughputs met and exceeded test criteria.
- SES Networks conducted a 3G field trial with Telenor Pakistan for over a month using actual subscriber traffic. The aggregated traffic peaked at 27Mbps with an average of 9Mbps per NodeB.

Proven Results for SES Networks' Customers

Certifications, pilots and testing with the world's leading companies in the mobile telecommunications space all confirmed O3b MEO satellite system capabilities elegantly handle mobile data traffic for hard to reach spots in an MNOs' network footprint (or expansion of that footprint). SES Networks has real world operators using the O3b MEO network to deliver real data to their subscribers, every day, all over the world.

ARCHITECTURES



Figure 1 Core Network Architecture





CASE STUDIES

CORE NETWORK – DIGICEL PNG

Digicel is a mobile network provider operating in 31 markets across the Caribbean, Central America and Oceania regions. Digicel Pacific is the leading telecommunications operator in six Pacific countries and has been working with SES Networks (previously O3b Networks) since July 2013 in Papua New Guinea, Samoa, Nauru, Vanuatu, Solomon Islands and Fiji.

Digicel had seen a need in markets across the world for increased internet connectivity, but nowhere was that need stronger than in the emerging market of Papua New Guinea.

Papua New Guinea (or PNG), with a population of 7 million, has a quickly expanding mobile subscriber base, but was limited primarily to providing voice services. Digicel wanted to offer data services as well to promote connectivity to applications and and broadband access to global content, truly connecting the people of PNG.

Digicel Pacific has upgraded capacity multiple times since launching with the O3b MEO service — a direct response to significant growth in internet usage due to Digicel's upgraded and enhanced 3G, and then 4G/LTE mobile network featuring the high-throughput, low latency O3b MEO connection.

"Digicel is looking to promote data usage over the next two years, so offering aggressive data plans, and having a high-performance connection to deliver on those plans, is absolutely essential. Existing customers in PNG who have not been using data are finding the new O3b-enabled data packages affordable, and usage has already seen a big jump."

Michael Murphy, CEO, Digicel Pacific

BACKHAUL - WARID LTE, PAKISTAN

Warid LTE offers state-of-the-art telecommunication services to almost 16 million subscribers across Pakistan. They boast the largest postpaid base, strong youth and prepaid brands, international roaming, and nationwide coverage.

Warid LTE has launched 4G/LTE service in major metropolitan areas around Pakistan, including Lahore, Karachi, Islamabad, Rawalpindi, Faisalabad, and Gujranwala. It has been difficult to justify the cost of laying terrestrial fiber to many other population centers that would be good candidates for 4G/LTE service. Warid LTE was looking for a backhaul solution to do this.

SES Networks' state-of-the-art O3b MEO satellite network allows Warid LTE to deliver 4G/LTE services to the edge of their network, where fiber cannot yet be easily installed.



"Utilising the O3b network, Warid will be able to deliver our LTE service to customers over satellite almost immediately. For many, this means leapfrogging past 3G and immediately experiencing LTE benefits. This will enable new applications and even new businesses to thrive in every part of Pakistan."

Muneer Farooqui, CEO, Warid LTE

CONCLUSION

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A COMPELLING VALUE PROPOSITION FOR GROWTH

SES Networks' O3b MEO solutions provide MNOs the ability to deploy new, compelling mobile data user experiences. As the only satellite network able to meet LTE latency standards, the O3b system supports data intensive applications now and in the future, providing high throughput up to 1.6Gbps (already meeting the 5G standard). Easy scaling makes future capacity increases for growth straightforward and simple with no "truck rolls" required.

SES Networks' implementation & performance is comparable to fiber with similar KPIs, user QoE, and lub / S1 configuration in the terrestrial template. SES Networks' O3b MEO-driven solutions typically have a lower cost to deploy and operate, especially for 4G/LTE.

BETTER CONNECTIVITY OPTIONS FOR LESS

Mobile data is rapidly growing in importance for every market because of a new wave of data-hungry applications and customer demand for a better user experience. This demand, when combined with the fiber-like capabilities of the O3b MEO network, is creating opportunities for operators to build and close the business case for 3G, 4G/LTE and in the future 5G in remote markets. Having a lower cost per Mb and increased data usage has enabled MNOs to increase ARPU, market share, and the number of subscribers, resulting in overall higher profitability.

Because of the lower altitude of the O3b MEO satellite constellation, the network meets 4G/LTE specifications. GEO satellites simply cannot currently provide the low latency needed to support LTE applications requiring latency to be under 500ms. In fact, with latency of under 150ms, the O3b MEO network is ideal for MBB services. The O3b MEO system enables MNOs to provide 4G/LTE services to customers anywhere on their network, even to remote and sparsely populated areas. SES Networks' high throughput, low latency solution means satellite can finally enable operators to provide high-performance data services across the entire network, and even to expand their network footprint.

The O3b MEO solution to provide MNOs 3G and 4G/LTE capabilities is tested and proven. SES Networks has been certified by Huawei Wireless MBB and Enterprise Labs and ZTE labs, and has passed successful pilots over Ericsson and Nokia. SES Networks has many MNO customers who are already seeing the benefits of O3b MEO powered solutions for 3G and 4G/LTE. SES Networks provides the MEO and multi-orbit system that can efficiently and quickly scale to enable MNO revenue growth from new mobile data services and new markets.

High-performance mobile data is the future of revenues for mobile networks, and SES Networks is the only choice to deploy in challenging, remote areas.

3G AND 4G/LTE FOR REMOTE, RURAL, AND UNDERSERVED AREAS

SES NETWORKS HEADQUARTERS

Johan van Oldenbarneveltlaan 5 2582 NE The Hague The Netherlands



Accra | Ghana Addis Ababa | Ethiopia Bucharest | Romania Dubai | United Arab Emirates The Hague | The Netherlands Istanbul | Turkey Johannesburg | South Africa Kiev I Ukraine Lagos | Nigeria London | UK Luxemburg | Betzdorf Madrid | Spain Miami | USA Mexico City | Mexico Moscow | Russia Munich | Germany Paris | France Princeton | USA Riga | Latvia São Paulo | Brazil Singapore | Singapore Stockholm | Sweden Warsaw | Poland Washington DC | USA

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