Our Connectivity . . .

MEO Evolution

PRESENTED BY

John Parkinson, MD, SES UK

17th September 2019

Agenda

- Overview of SES
- SES Medium Earth Orbiting Constellation
  - mPower
  - mPower *Inclined*
  - *mPower+*
- Summary

SES the Company

History

1985

SES, Europe's first private satellite operator, is founded in Luxembourg and signs launch agreement with Arianespace

1991

Co-location – an innovation by SES. SES's first satellite co-located to multiply the number of services that could be transmitted from one position.

1995

SES goes digital – a huge attraction for channel providers was SES's pioneering of digital broadcasting technology.

2001

SES acquires Americom from GE. SES GLOBAL is established with two operating companies: SES ASTRA and SES Americom

2013

SES Launches its first Ultra HD demo Channel

2016

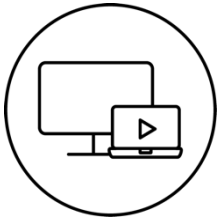
SES forms MX1 and acquires O3b to significantly enhance existing video and data capabilities

2017

SES pioneers reusable technology with the first ever reusable rocket satellite launch on Space X Falcon 9

Two Key Market Verticals

SES focuses its differentiated strategy on value-added, end-to-end solutions in two key market verticals



Video

Technical reach of 325 million TV households worldwide, delivering over 7,500 TV channels and >2,500 HD channels, 33% of all SES channels are HD

Networks

Widebeam and GEO/MEO HTS capacity and teleport services for >300 enterprise customers, 99% global coverage of global maritime and aeronautical traffic, 62 governments in 28 countries

Fixed Data

+1 million simultaneous fixed internet connections supported by SES

>300 customers

Mobility

>2,500 aircraft served by SES satellites

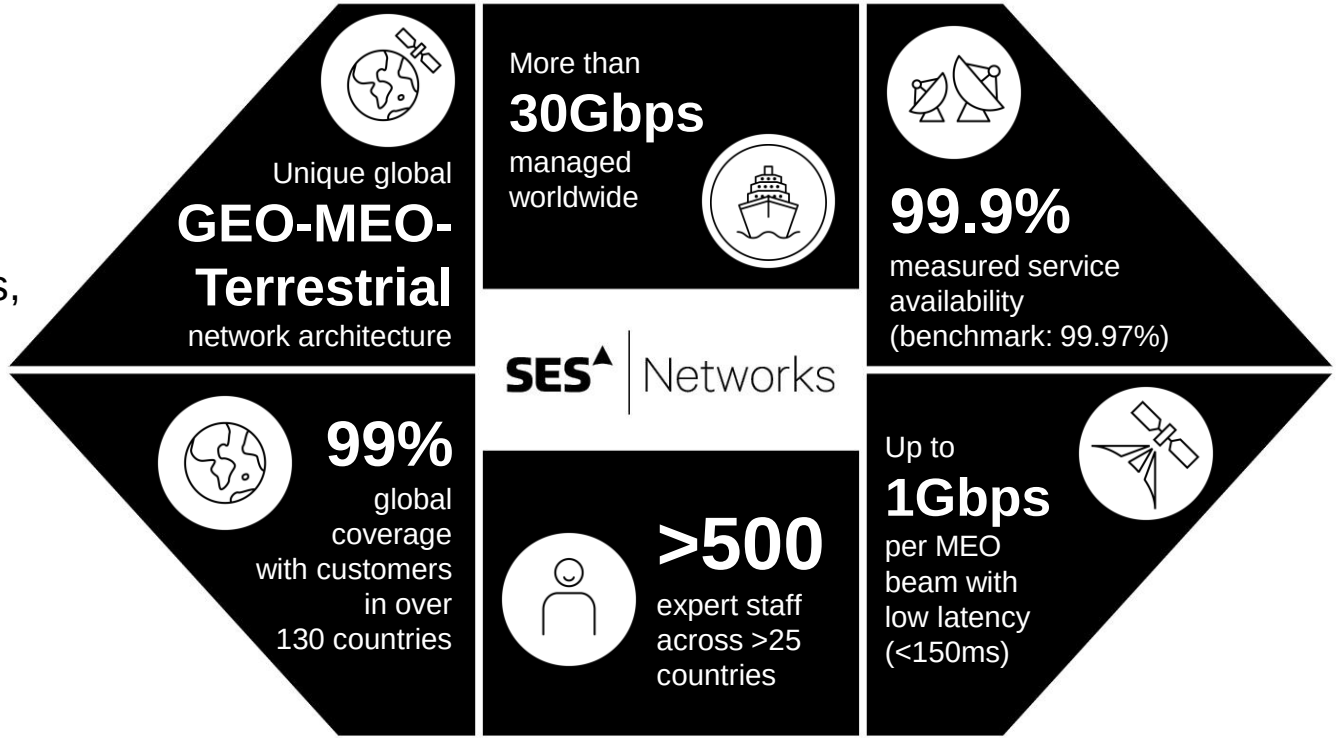
Government

Serving 62 government entities in 28 countries

Participant in >5 PPP

SES Networks at a Glance

- **SES Networks is the only provider** of networked communications across both GEO and MEO satellites, providing far more flexibility and enabling a far greater array of optimised applications for customers, wherever they are.



A Diverse Fleet in the Sky

SES Networks

GEO WIDE BEAM

- Over 50 satellite constellation
- Broad coverage in less dense areas
- Well-suited for applications such as content multicasting, enterprise connectivity in remote regions
- Serving multiple data applications and customers

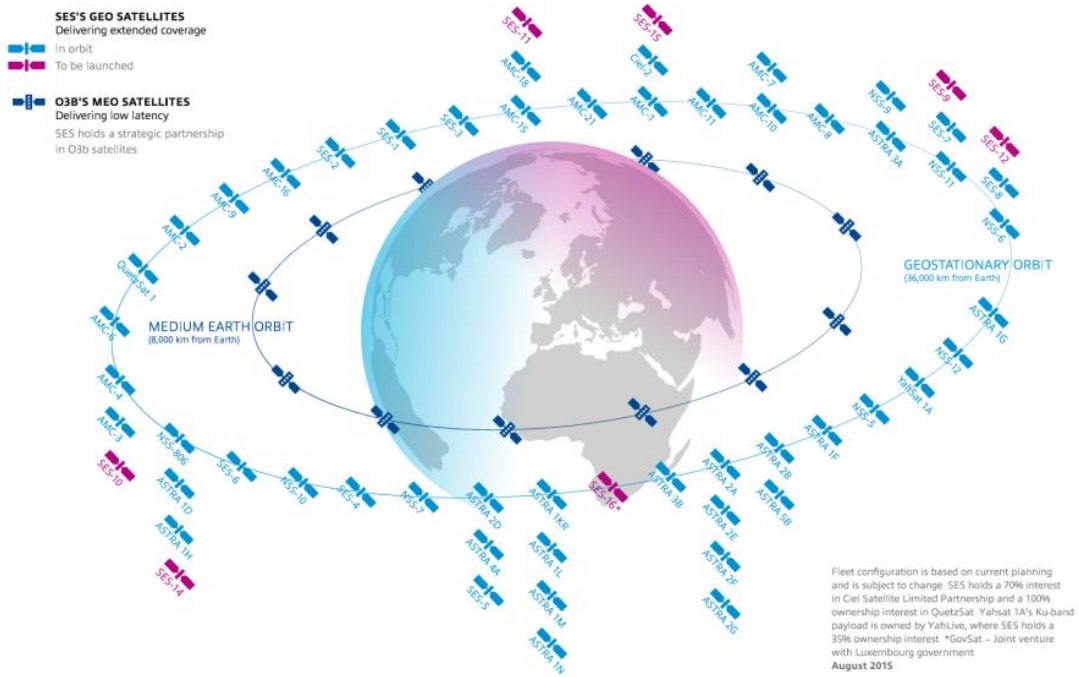
GEO HTS

- Two GEO HTS satellites, with two additional ones planned
- Enhanced downstream connectivity for video and data transmission
- Reduced cost per MHz, improving value proposition for data applications

MEO HTS

- 20 MEO HTS satellites with an additional 7 under procurement
- Up to 1Gbps per MEO beam with <150ms latency
- Optimal for time sensitive applications such as voice, videoconferencing

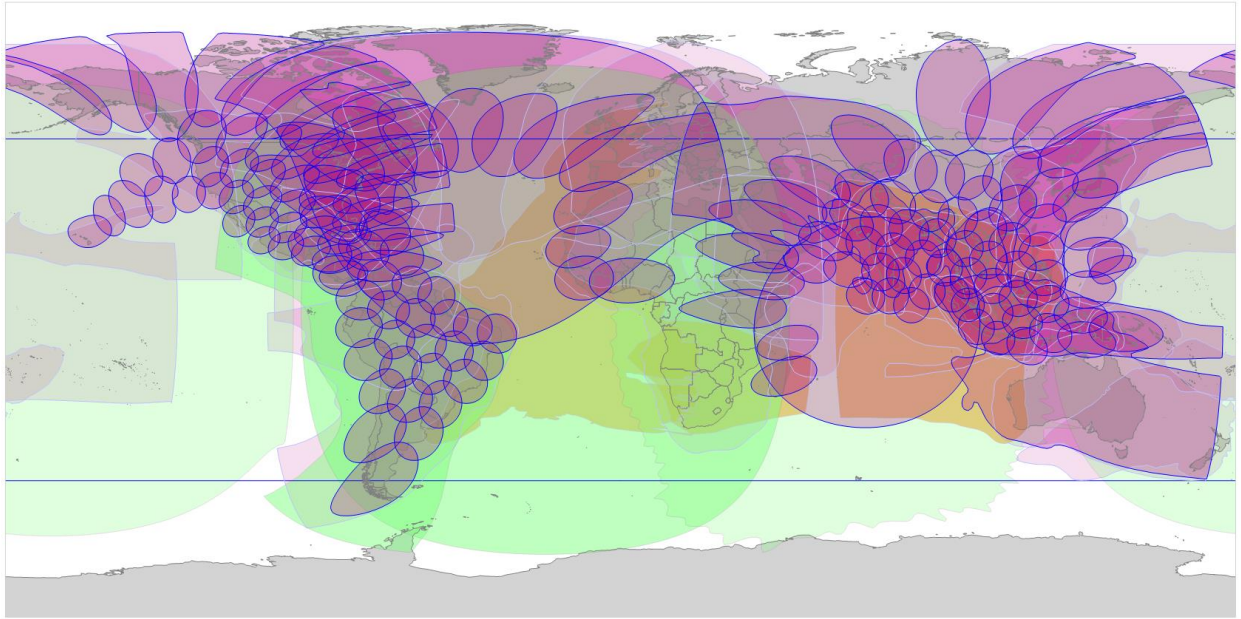
SES Network Fleet Access



SES has satellites in GEO Orbit in C, Ku, Ka, and MIL Ka & X band Satellites through LUX GOVSAT a Public Private Partnership. It also is the only provider of MEO Orbiting Constellation in Ka-band.

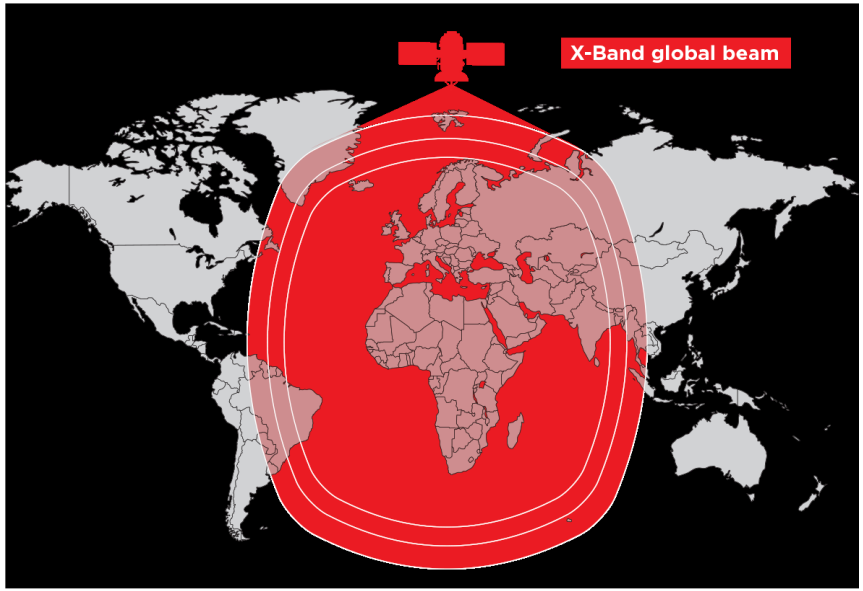
Best of Breed, Best Available Network to meet the Customers Needs

Combining the strengths of MEO & GEO

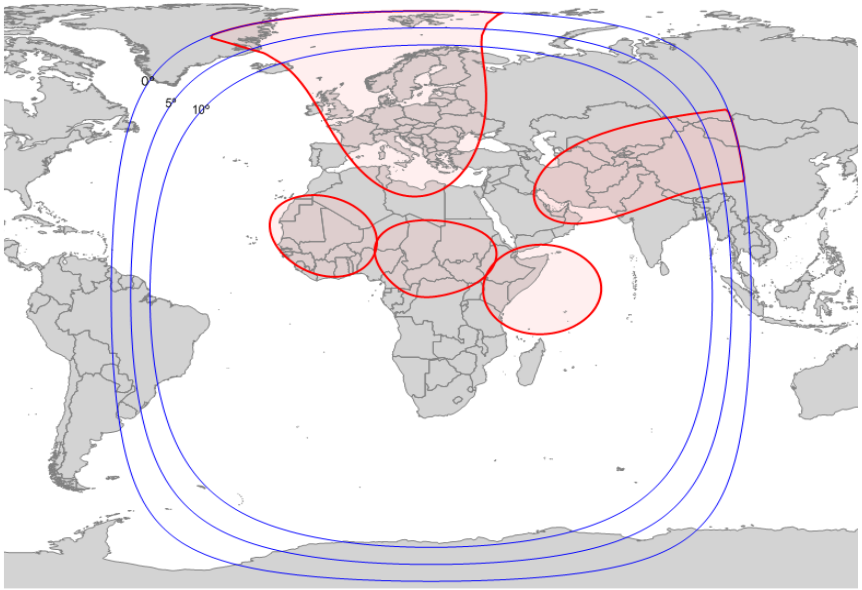


Primary satellite operator with MEO and GEO constellations in service… today

X-Band on LUX GovSat

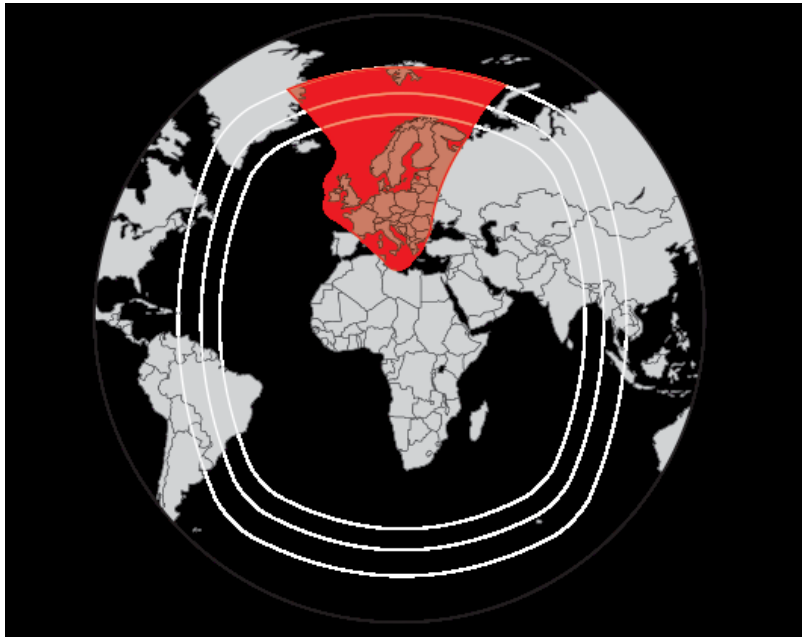


X-Band Global Beam

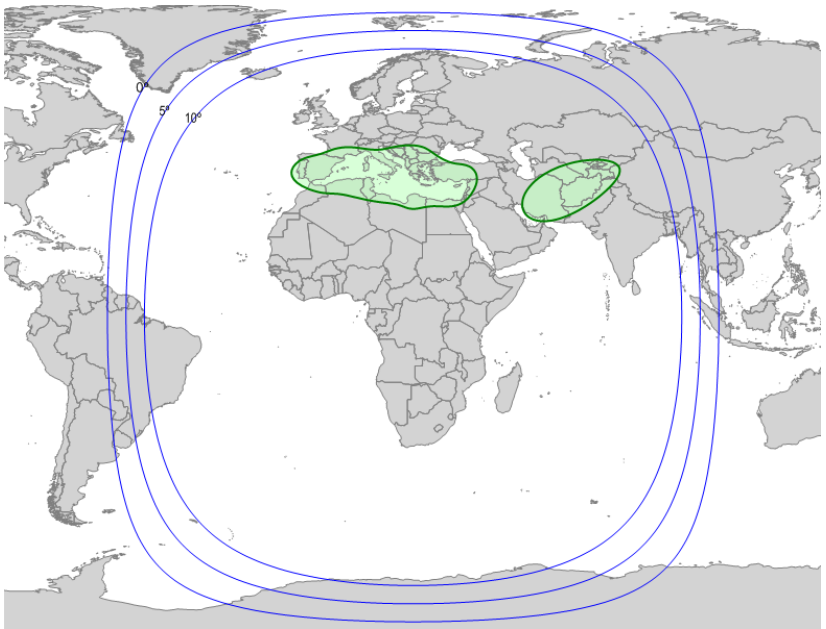


X-Band Mission Beams

Mil Ka-Band on LUX GovSat



Ka-Band Anchor Beam



Example of Mil Ka-Band Steerable Beams

Putting the Pieces Together

FLEXIBLE, MULTI-BAND SATELLITE ARCHITECTURE

- Addresses dual requirements of ubiquitous coverage and faster data speeds
- Augmenting HTS with legacy wide beam technology for broader coverage in less dense areas

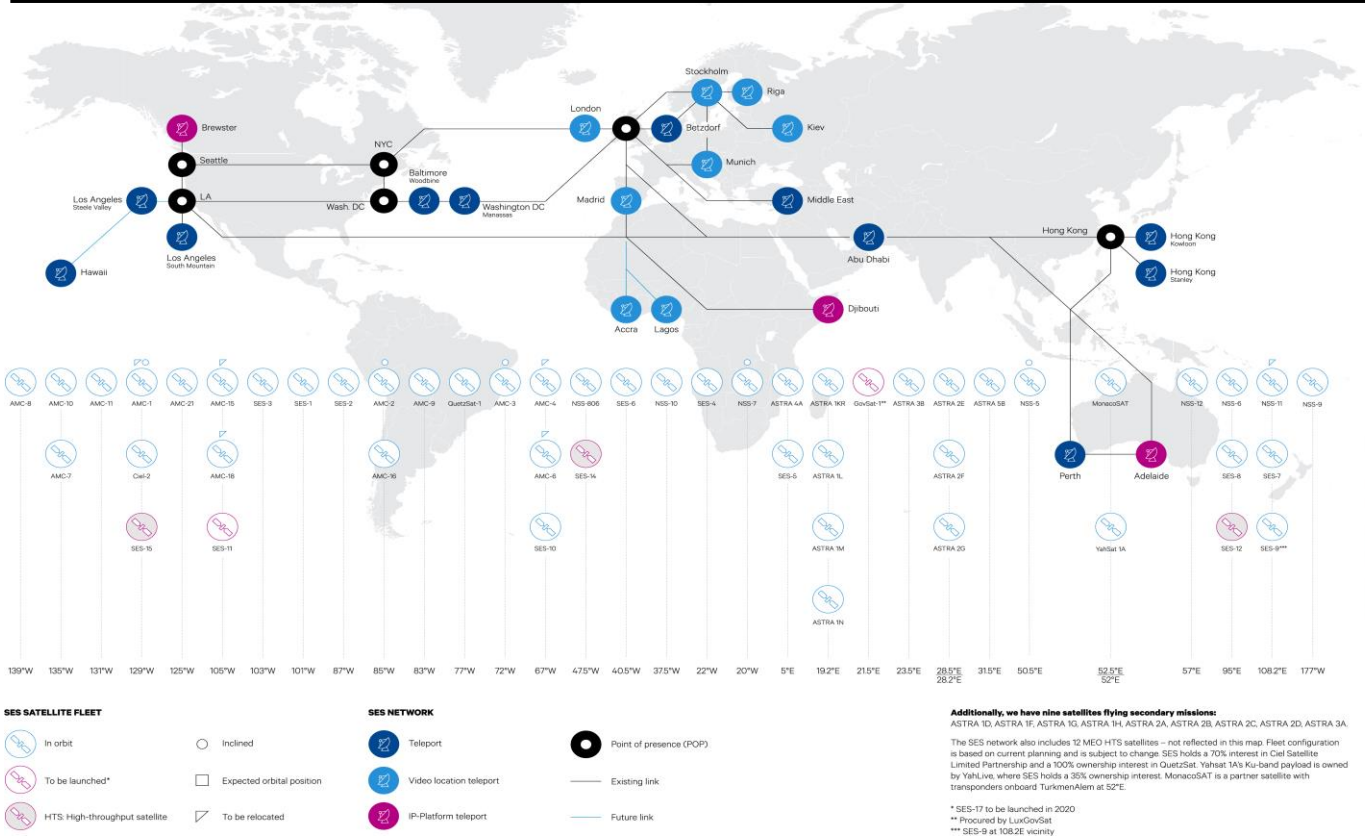
A FLEXIBLE AND SCALABLE GROUND SYSTEM

- Manages a diversity of frequency bands and satellite types
- Real-time network performance monitoring ensures bandwidth is optimized and SLAs are met
- High performance remotes

A RANGE OF SERVICE MODELS

- Supports multiple service delivery models, including platform services, end-to-end managed network services
- Enables flexible commercial options, reducing complexity and risk

Network Map



SES SATELLITE FLEET

- In orbit
- To be launched*
- HTS: High-throughput satellite
- Inclined
- Expected orbital position
- To be relocated

SES NETWORK

- Teleport
- Video location teleport
- IP-Platform teleport
- Point of presence (POP)
- Existing link
- Future link

Additionally, we have nine satellites flying secondary missions:
ASTRA 1D, ASTRA 1F, ASTRA 1G, ASTRA 1H, ASTRA 2A, ASTRA 2B, ASTRA 2C, ASTRA 2D, ASTRA 3A.

The SES network also includes 12 MEO HTS satellites – not reflected in this map. Fleet configuration is based on current planning and is subject to change. SES holds a 70% interest in Ciel Satellite Limited Partnership and a 100% ownership interest in QuetzSat. Yahsat 1A's Ku-band payload is owned by YahLive, where SES holds a 35% ownership interest. MonacoSAT is a partner satellite with transponders onboard TurkmenAlem at 52°E.

* SES-17 to be launched in 2020
** Procured by LuxGovSat
*** SES-9 at 108.2E vicinity

Industry-leading network performance

99.9% NETWORK AVAILABILITY

SES SATELLITE FLEET

- In orbit
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SES NETWORK

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Next-generation network for our customers' growth

SES Networks

70+

satellites covering

99%

of the globe and world population

Unique

GEO-MEO

constellation complemented by a ground segment, together forming a flexible network architecture that is globally scalable

mPower

Driver of

INNOVATION

in building a cloud-scale, automated, "virtual fibre" network of the future. Leading in the industry's most influential standards groups

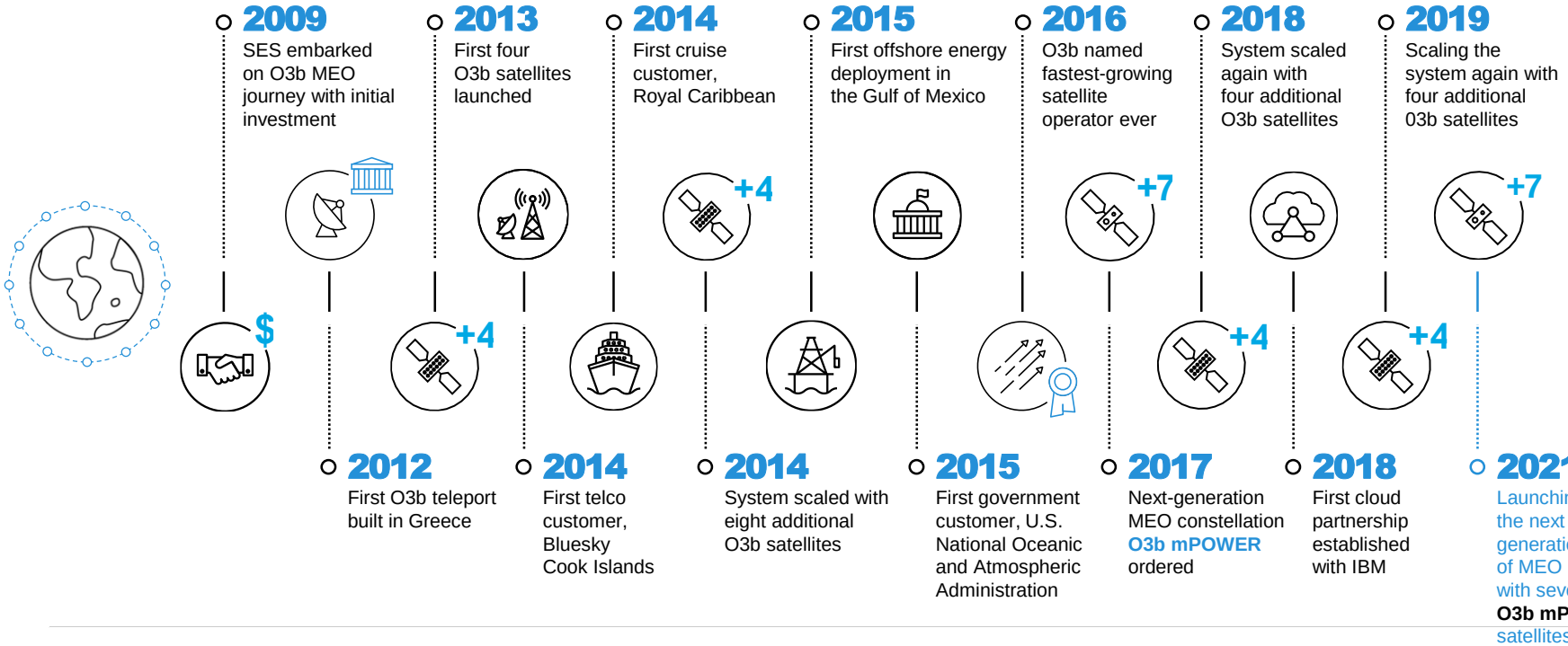
CE 2.0 MEF CERTIFIED

SES O3b MEO Constellation

The Journey MEO to mPOWER

Bold Vision… Proven Impact

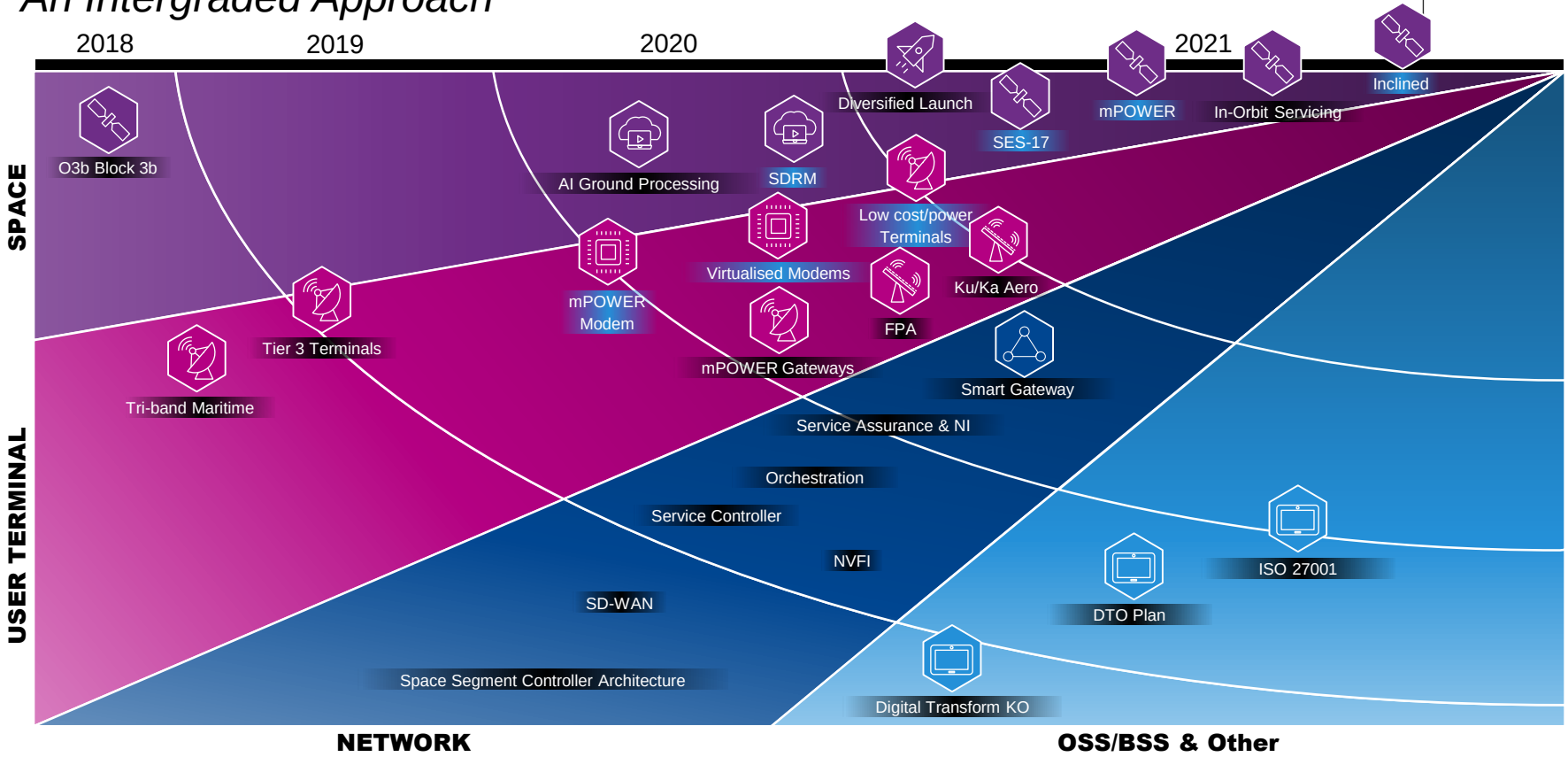
SES | Networks



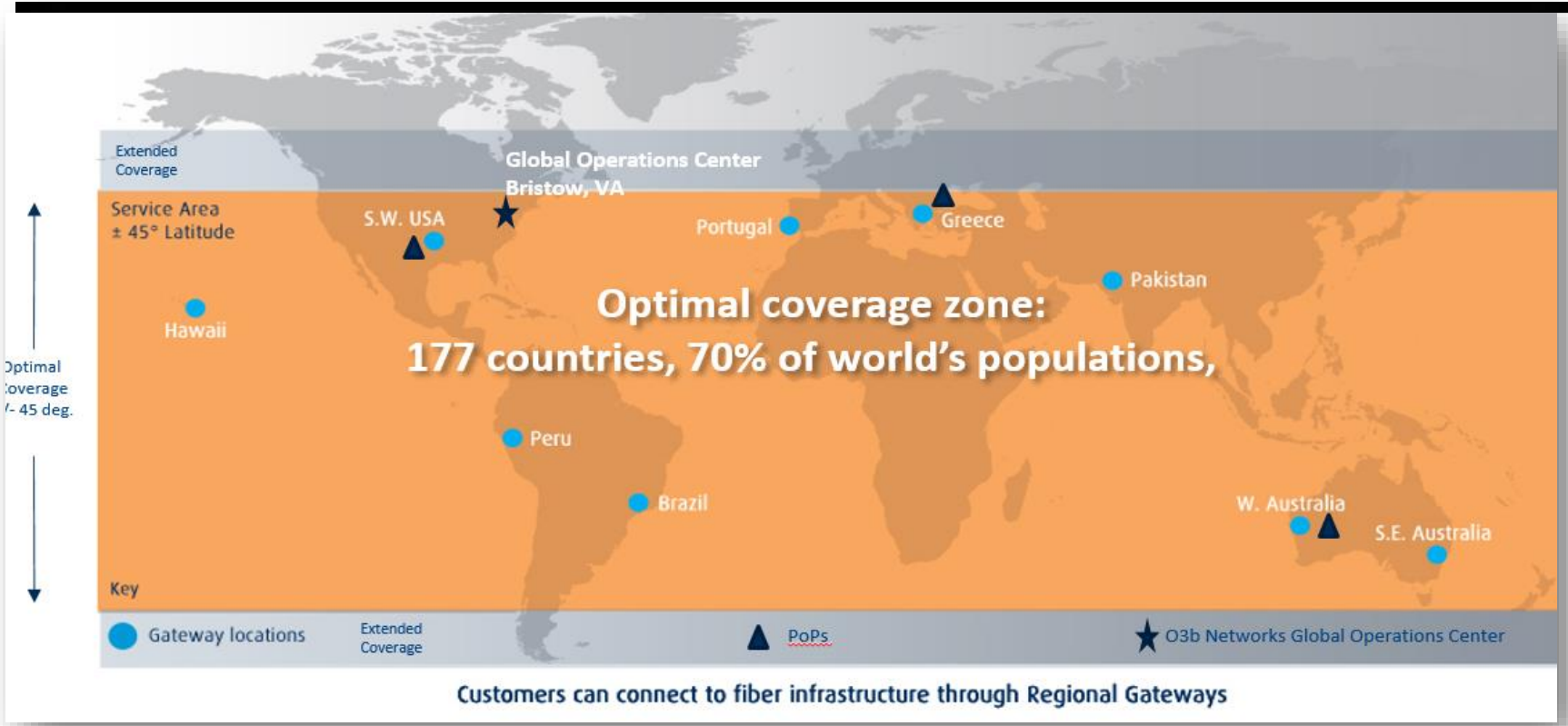
Technology roadmap

An Intergraded Approach

SES Networks

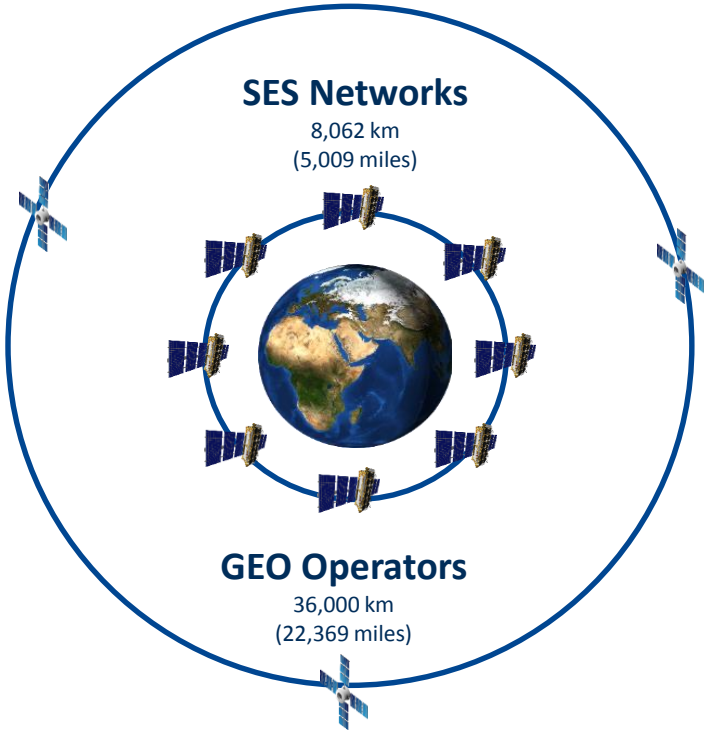


Coverage Area of O3b MEO



A Different Kind of Satellite

SES MEO (O3b) Constellation

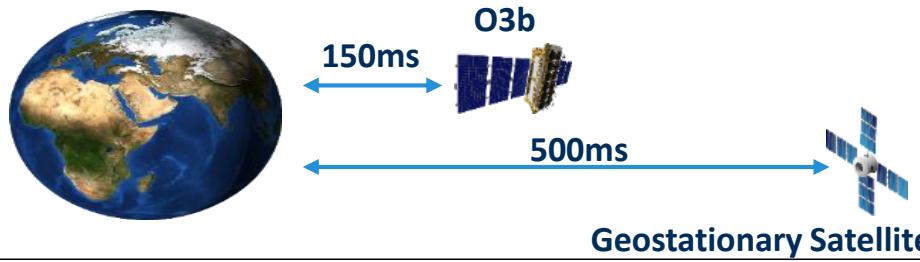


A different kind of satellite:

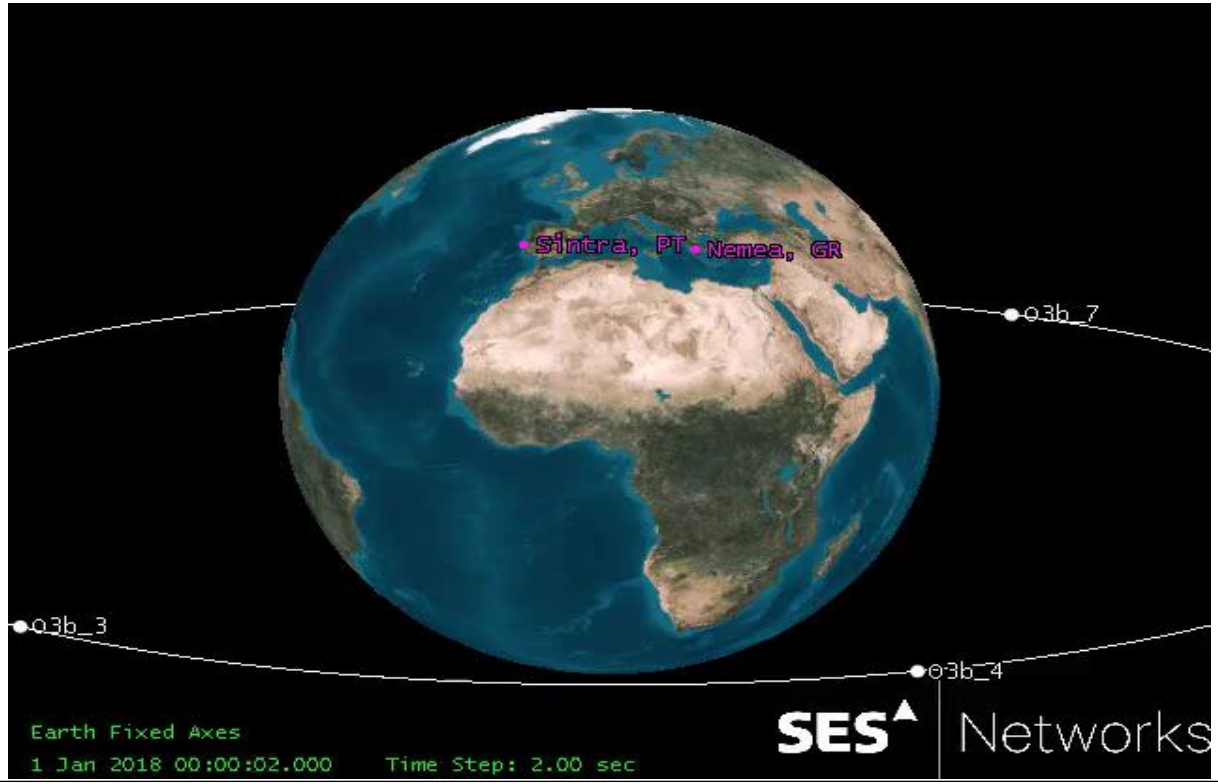
- MEO reduces delay by 75% and increases throughput significantly compared with GEO
- Lower cost to build and launch

O3b is <u>the first satellite constellation built with IP and mobile networks in mind</u>

- O3b's cost advantage enables the business case for sites that are not possible with GEO or fiber
- O3b's higher throughput and lower latency dramatically improves satellite communication services



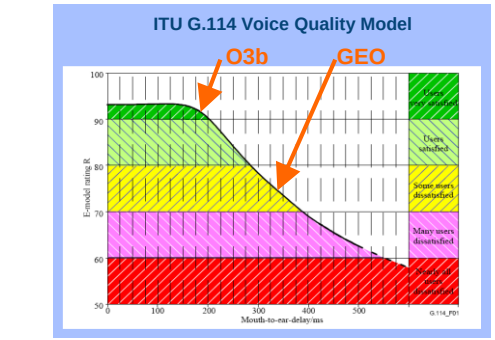
Current SES (O3b) MEO Constellation



What SES Networks Brings Today

On our MEO Constellation

- Secure & Reliable –
  - Low Probability of Jamming, as assessed by the Office of Secretary of Defense, Joint Vulnerability Assessment Branch
  - Encryption Assessment by SOCOM, US Navy, CODA Lab & USMC
  - Cyber Security
- Low latency, guarantee 150ms or less Roundtrip
- High throughput, up to 2 Gbps to a single terminal
  - 1.2 Gbps to a 2.4m terminal
- Carrier grade quality which enables and optimize video, voice, data and applications
  - Meets Metro Ethernet Compliant (MEF) International carrier standard
  - Meets International Telecommunications Union at the highest level, under ITU G. 114 Voice Quality Model
- Beam Mobility by user, Secure beam mobility without O3b interaction



These attributes enhance government's ability to operate and response with disparate forces to work together to communicate and synchronize their efforts

Online gaming – Mulitplayer Console

GEO

O3b

(Xbox 360 – Call of Duty)

O3b mPOWER

The Next Generation, Unleashing the Opportunities

Future-proof Solutions

O3b mPOWER – Unleashing Opportunities

SES Networks

CURRENT MEO

12 satellites in service[1] plus eight to be launched in 2018/2019

- Small cities and towns
- Large multi-national organisations
- Fixed rigs/larger production vessels
- Large cruise ships
- Larger fixed/mobile installations

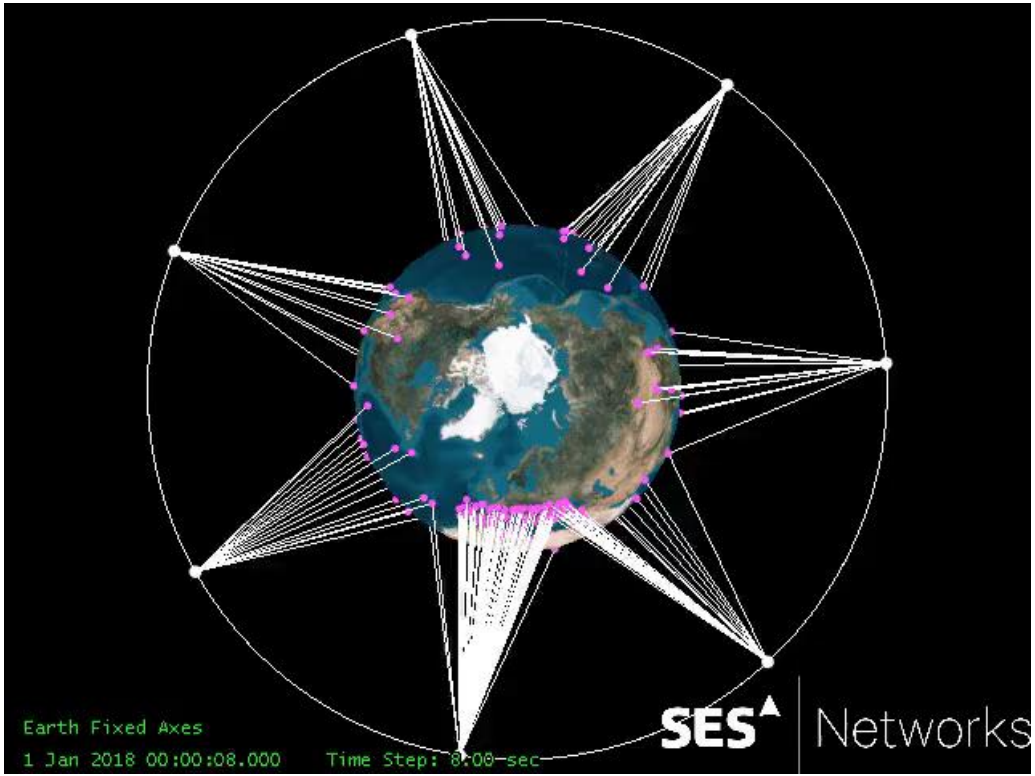
NEW OPPORTUNITIES WITH O3b mPOWER FROM 2021

Seven super-power satellites

- Multiple units in theatre
- VIP aircraft
- Commercial aircraft
- Inter-regional commercial ships
- Large yachts
- Smaller cruise ships
- Smaller mobile production vessels
- Cloud access
- Data centres
- Remote offices
- Small towns and remote locations

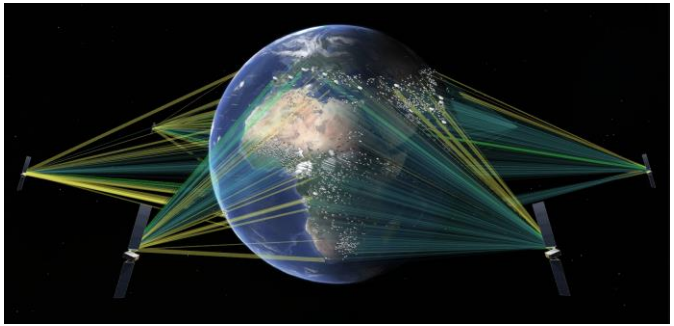
1) Comprising nine operational satellites and three held as in-orbit back-up

O3b mPOWER


Earth Fixed Axes
1 Jan 2018 00:00:08.000
Time Step: 8.00 sec
SES Networks

O3b mPOWER

- State of the art encryption standards
  - **Military grade Command and Telemetry crypto (CNSSP-12 compliant)**
  - **Crypto agnostic for customer services**
- Bespoke Service
  - Multi Application with tailored coverage supported by MEO latency of < 150 msec
  - **Full flexibility on gateway location (in theater and/or key POP's) with the ability to provide multiple routes to a single user terminal.**
  - **Waveform agnostic with fully transparent repeater**



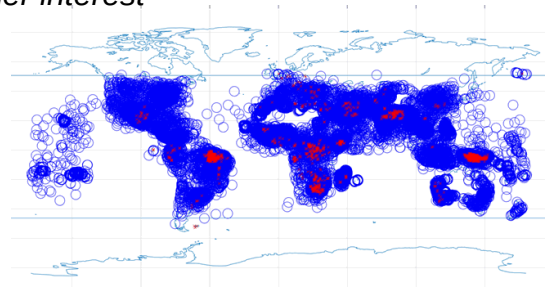
- Robust Service Plan
  - MEO orbit provides disaggregation in addition to natural resilience of a constellation architecture (i.e. would need to lose all satellites to remove capability)
  - Features such as tracking orbit, large/configurable frequency band, ability to null, small beam footprint and ability to access multiple satellites from a single terminal provide significant defense against jamming.

O3b mPOWER Constellation at MEO

(Continued)

Ka-Band GLOBAL Service

- Frequency Bands
  - **Capability to channelize between 15 MHz and 2.5 GHz to a single terminal**
  - Full Commercial K-band, potential to implement Military Ka *contingent on customer interest*
- Coverage
  - **+500 to 4000 beams per SC vs 10 beams per SC today, dependent on final design**
  - Capability to create tailored beams in accord with evolving in-theater requirements
  - **Capability to securely update beam locations realtime based on terminals/customer needs**
  - **Global coverage +-50 degrees latitude**
- Very high throughput possible per terminal
  - Throughput per terminal largely limited by terminal capabilities; peak bitrate per user up to 10 Gbps. **Each satellite having 200Gb of capacity verses 20Gb today**
  - Significant return capability with 20 dB/K G/T GEO equivalent performance, supporting next generation ISR demands.



Next Generation, low latency system with fully customizable beam laydowns which can be adapted to meet changing theater demands and deliver unprecedented throughout per beam

O3b mPOWER *Inclined*

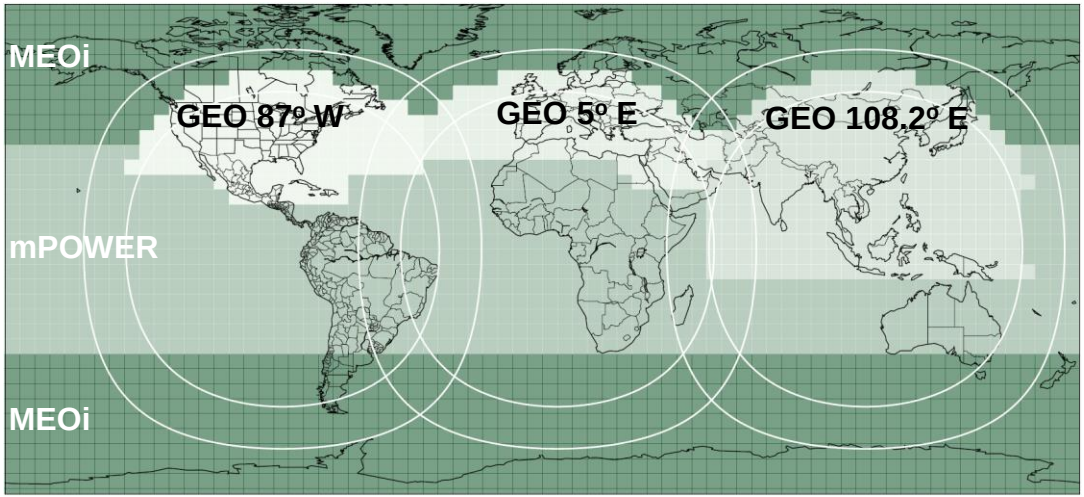
Unleashing the Opportunities in the Polar Regions

Inclined Strategy for Global Coverage

Building on the mPower Architecture

SES Networks

- SES is exploring various orbital and architectural configurations for an inclined solution
- Current direction is to leverage MEO equatorial, GEO and MEO inclined in a combined solution to maximize performance and coverage, in addition to overall elevation angles.



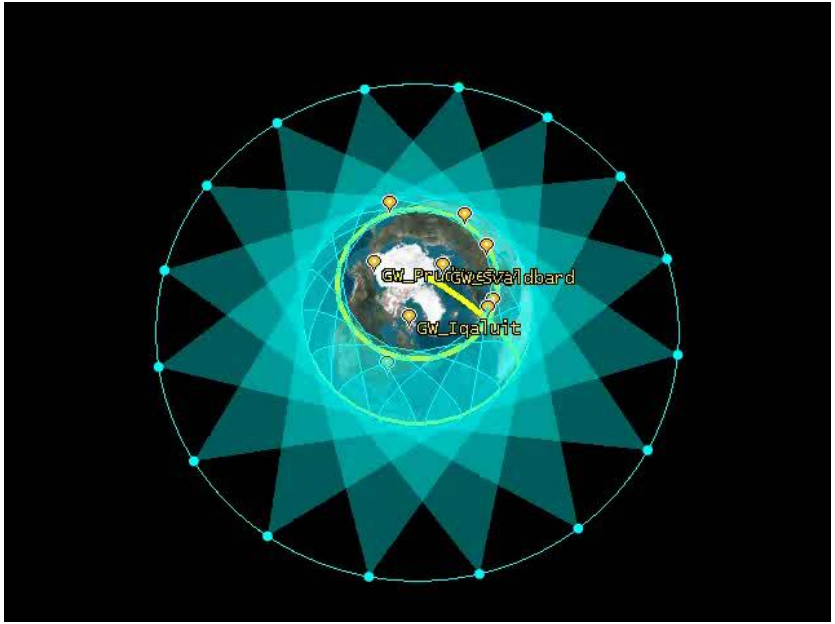
Hybrid solution allows each asset to use its strengths

Next Generation Ka-band

Network with Global Coverage

SES Networks

- Scalable architecture allows:
  - Global Coverage
    - mPOWER + 3 GEO's + single plane of 5 (or more) satellites in MEOi
  - Increased efficiency with additional launches
    - 2nd MEOi plane improves elevation angle
    - Allows all MEOi satellites to be used at low latitudes



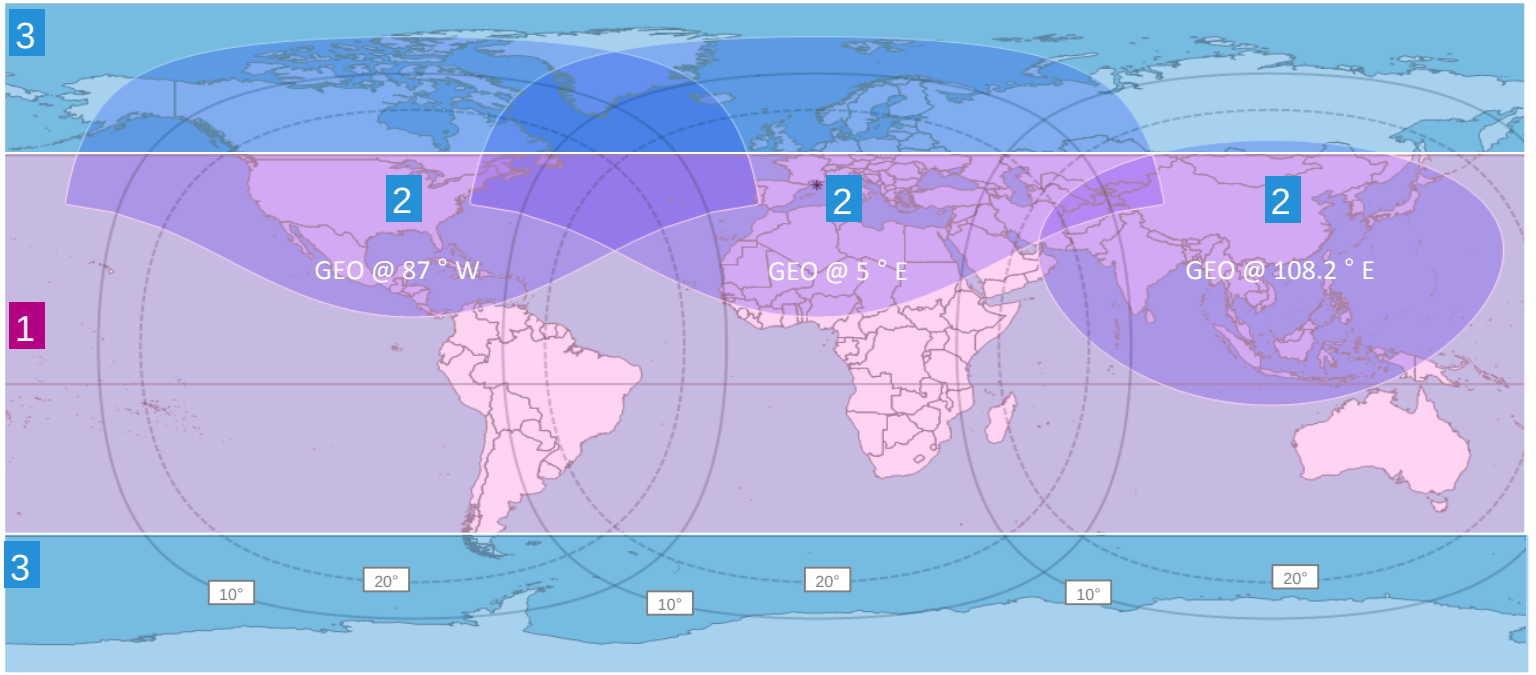
mPower +

The Marriage of GEO and Multiple MEO Constellations

Next Generation Ka-band

Network with Global Coverage

SES Networks

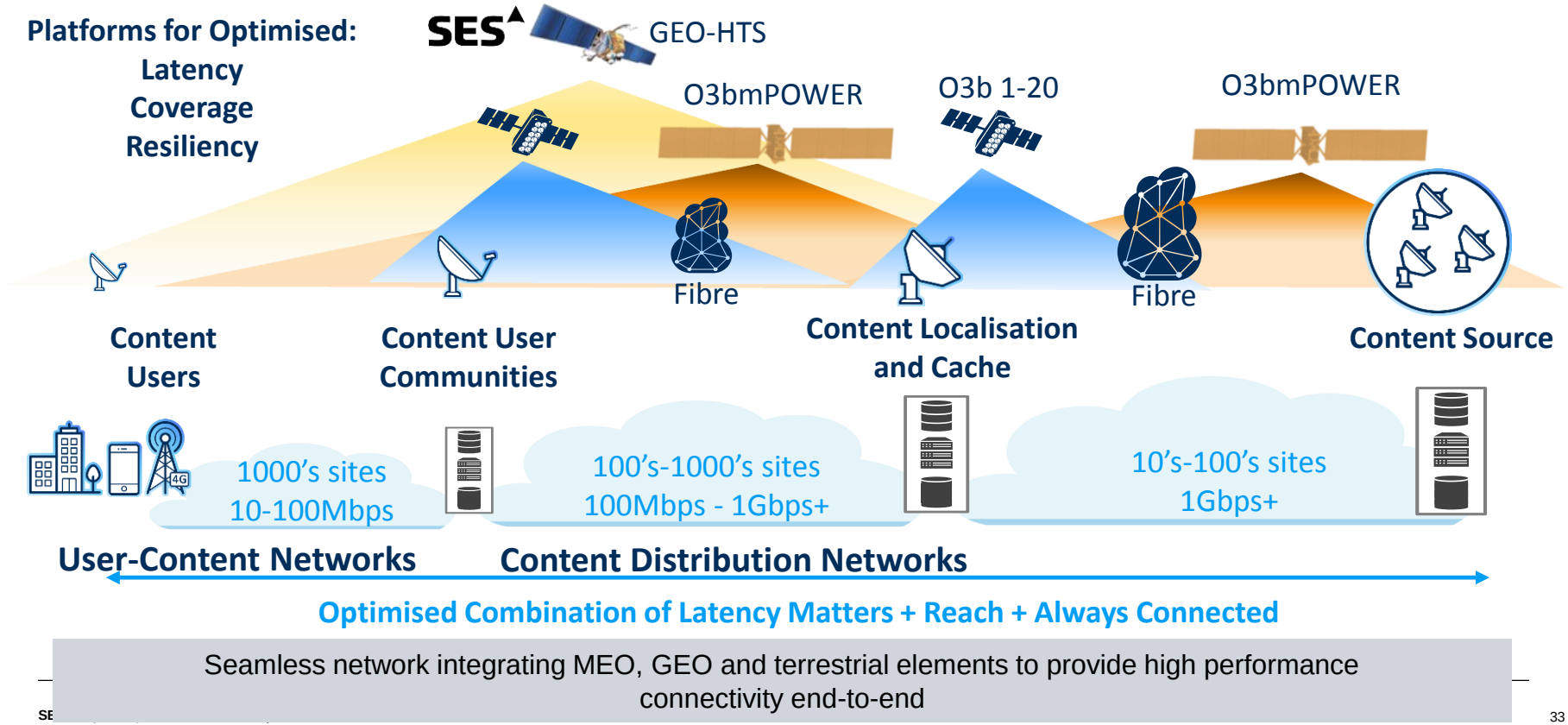


A seamless, global Ka-band network through dynamic resource management of an all digital architecture utilizing Software Defined WAN Techonology

O3b mPOWER Global Platform

Enabling truly global cloud-scale connectivity

SES Networks



Seamless network integrating MEO, GEO and terrestrial elements to provide high performance connectivity end-to-end

Summary

SES Networks – 3 years on….

- **Immediate** deployment of Gbps- Tbps data, network available in months, not years
- **Fiber-like** Global connectivity from space (latency under 150ms)
- **Secure**, with inherent anti-jamming capabilities, open source, bent pipe solution enables crypto solutions
- **Fully Flexible** delivering from Mbps up to Tbps per island/location, to any location
- **Combining** SES O3B for **Land Network** + SES GEO capacity (any band) for **Mobility**
- **Satellite Roaming** – Fully automated switching between MEO-GEO (it just works)
- **Full managed service** on an agreed QoS

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SES | Networks

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