GLOBAL SATELLITE COALITION

Session 2: GSO Constellations (MSS/FSS)

2a: Inmarsat's GX Constellation

2b: Intelsat EPIC

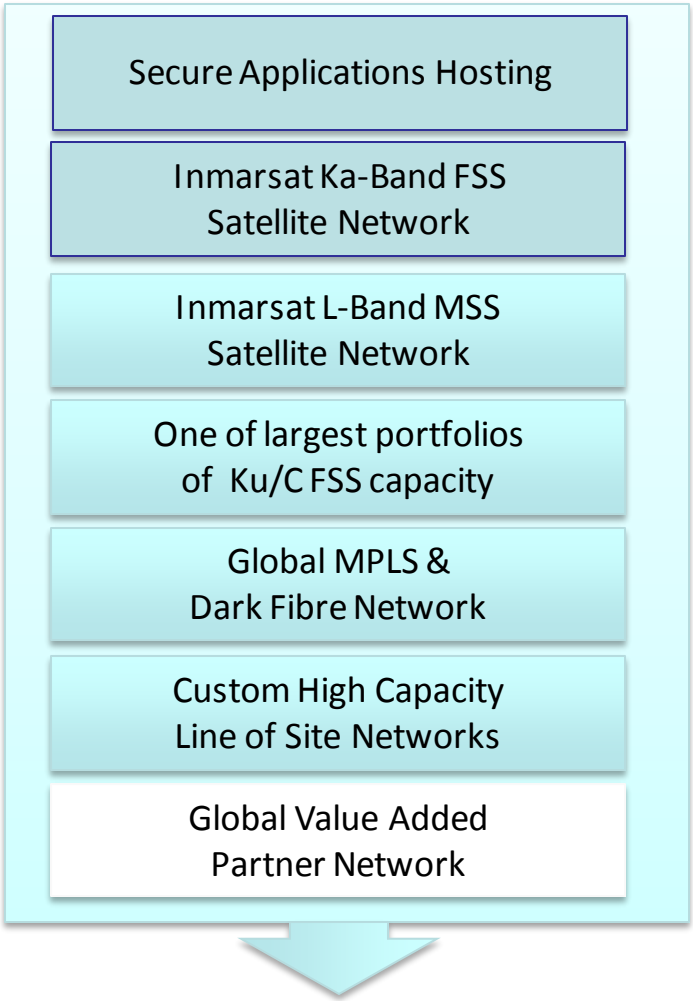
2c: Viasat's 3rd Generation

GLOBAL SATELLITE COALITION

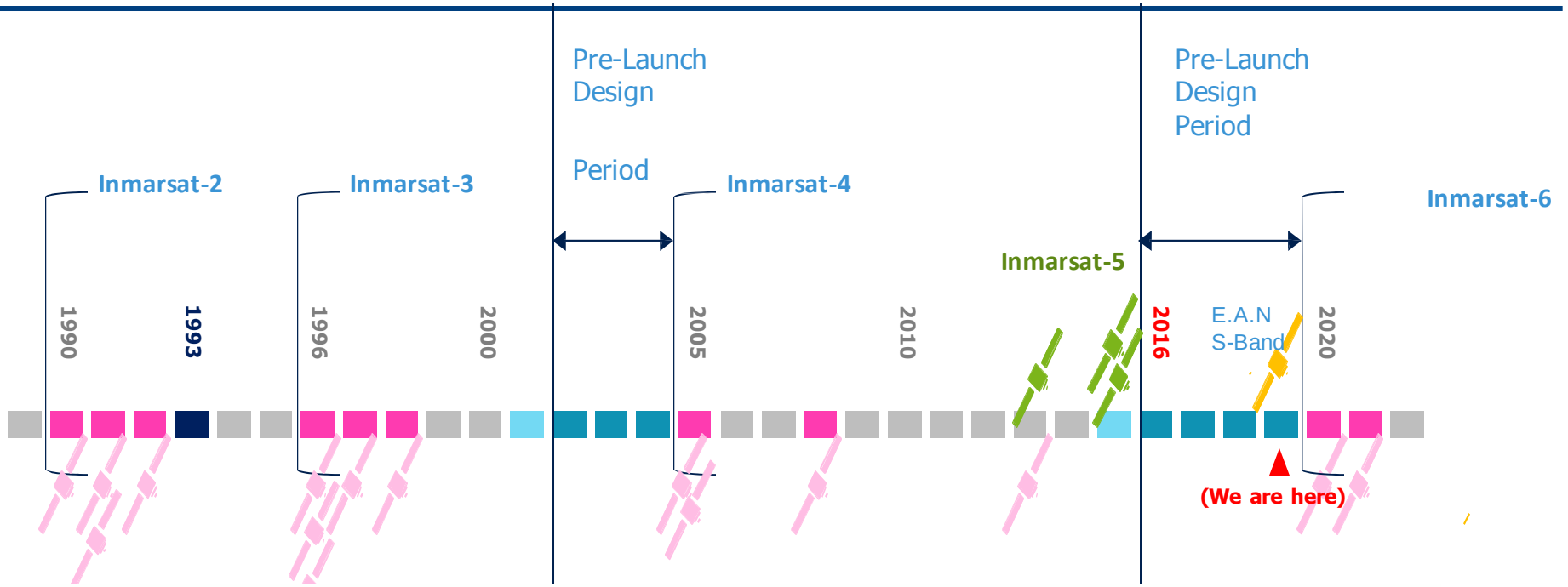
Session 2a: Inmarsat's GX constellation

Inmarsat – Who We Are

- Formed in 1979 as an International Government Organization – 'owned' by [42] nations.
- Now a FTSE 100 PLC
  - $2.0 billion turnover, 2000 people, global workforce 60 Counties
  - Extremely financially robust
- Committed to remaining major provider of the Maritime Safety Service as a public service globally
- Market leader in Mobile Satellite Services (>50% Market share)
- One of largest global providers of Mobile Satellite capacity
- One of the largest providers of Private High Capacity
- >99.9% Network Availability.
- 24x7 Support Globally



Evolutionary Development – Space Segment with advances in technology in L, S & Ka bands

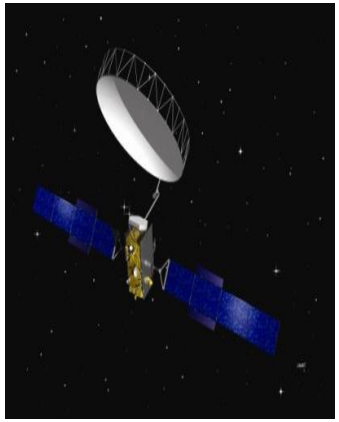


Coverage	Global Beam	Global Beam+5 Wide Spots	Global+19 Wide Spots+228 Narrow Spots	
Mobile Link EIRP	39 dBW	49 dBW	67 dBW	
Power Generation	1.2 kW	2.8 kW	14 kW	22 kW
Channelisation	4 channels of 4.5-7.3 MHz bandwidth	46 channels of 0.9-2.2 MHz bandwidth	630 channels of 200 kHz bandwidth	750 channels of 200 kHz bandwidth
Solar Array Span	14.5 m	20.7 m	45.0 m	
Satellite Dry Mass	700 kg	1000 kg	3000 kg	
Total Launch Mass	1500 kg	2050 kg	5960 kg	6600 kg

Inmarsat - a Pioneer in Mobile Satellite Communication

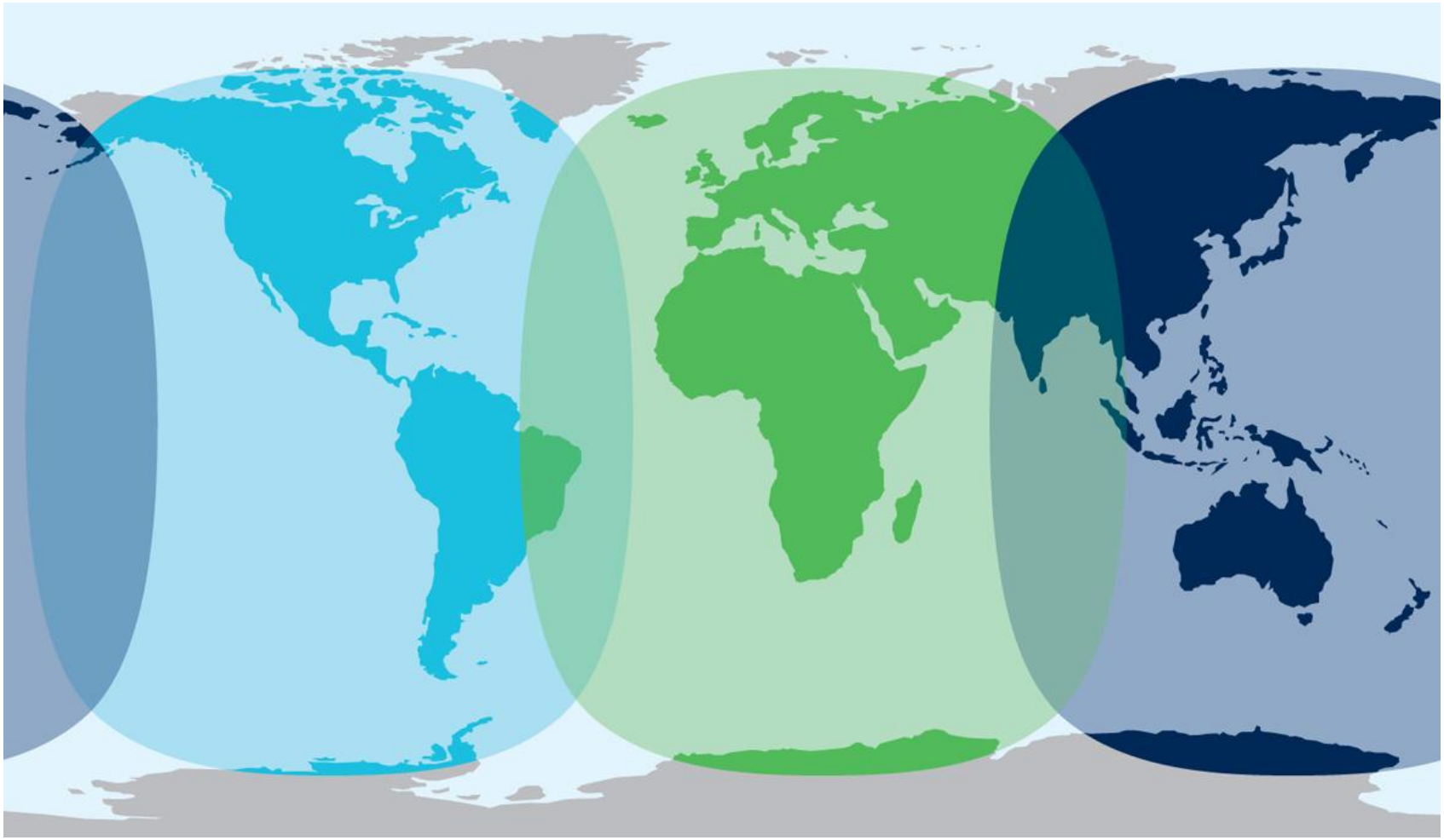
- Inmarsat currently operates 14 geostationary satellites
- Inmarsat 2 from 1990, Inmarsat 3 from 1996, Inmarsat 4 from 2005
- Alphasat from 2013
- Global Xpress from 2013

	Inmarsat 2	Inmarsat 3	Inmarsat 4	Alphasat	Global Xpress
Band	L band	L band	L band	L band	Ka band
Payload delivery	Global beam	Global beams & 7 wide spot beams	19 wide spot beams & ~200 narrow beams	Wide spot beams & ~228 narrow spot beams	72 channels per satellite with high capacity payload



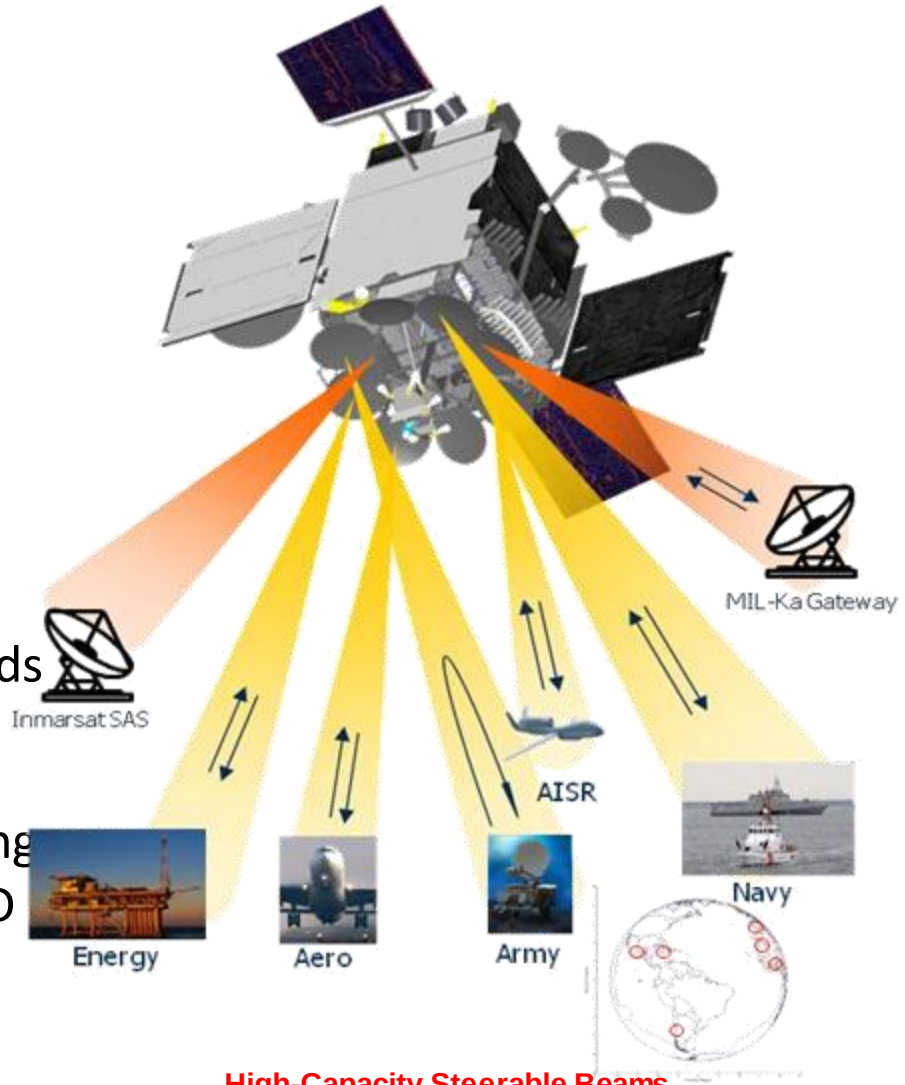
GLOBAL SATELLITE COALITION

Inmarsat 4 MSS Global Coverage



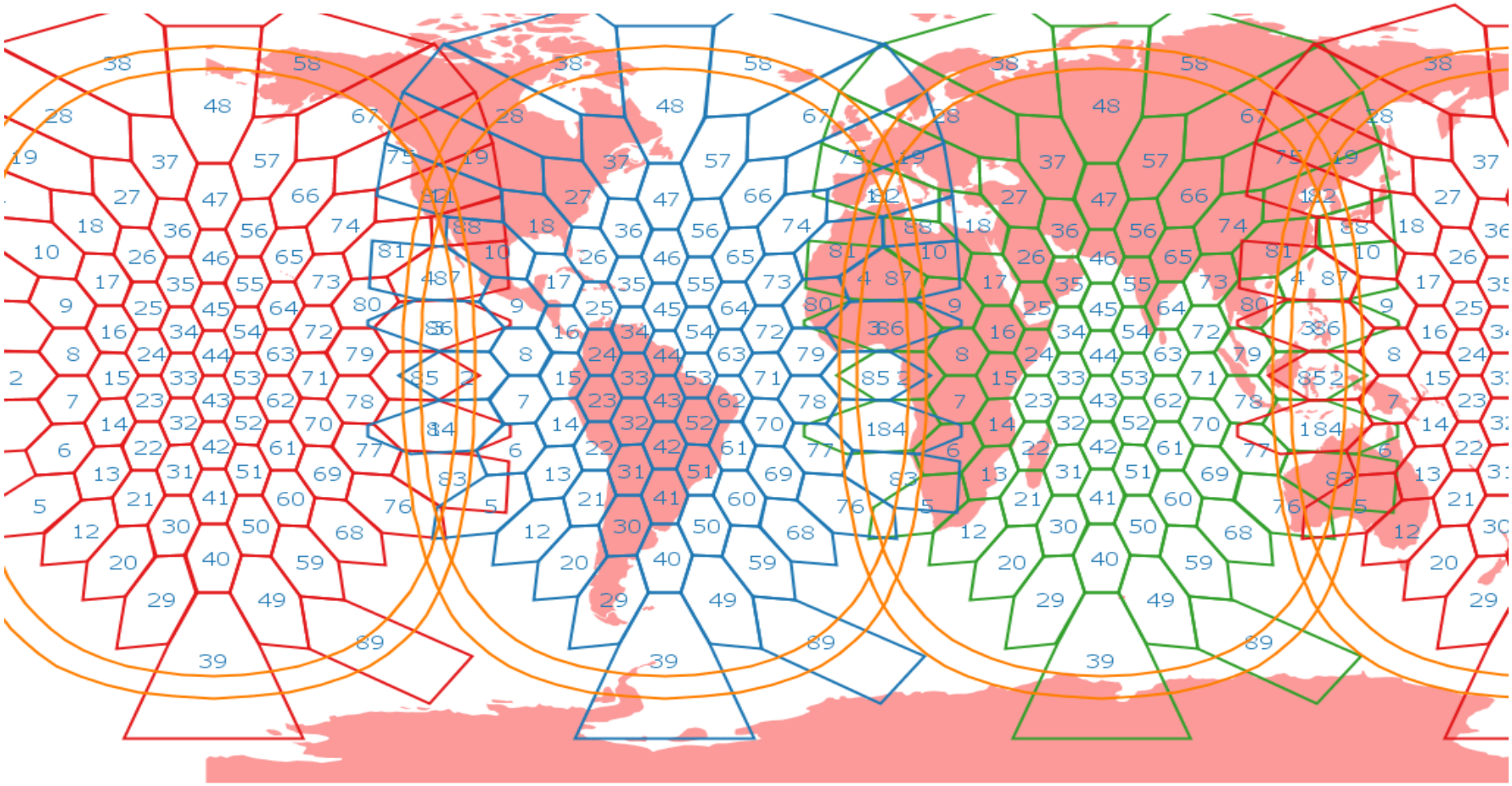
Inmarsat-5 GlobalXpress®

- The ONLY global Ka-band commercial / military broadband service
  - Four geostationary satellites
  - Global fixed coverage (up to 5/50Mbps to 60cm)
  - High-capacity spot beams (40-740MHz)
- Low cost commercial terminals
  - Maritime, Aero, Land
  - Seamless roaming, open standards
- Trusted space/ground network
  - US Type-1 encrypted commanding
  - Secure GX supports up to US DoD MAC-I



High-Capacity Steerable Beams (com'l / mil-Ka)

GX – Ka Band Global coverage



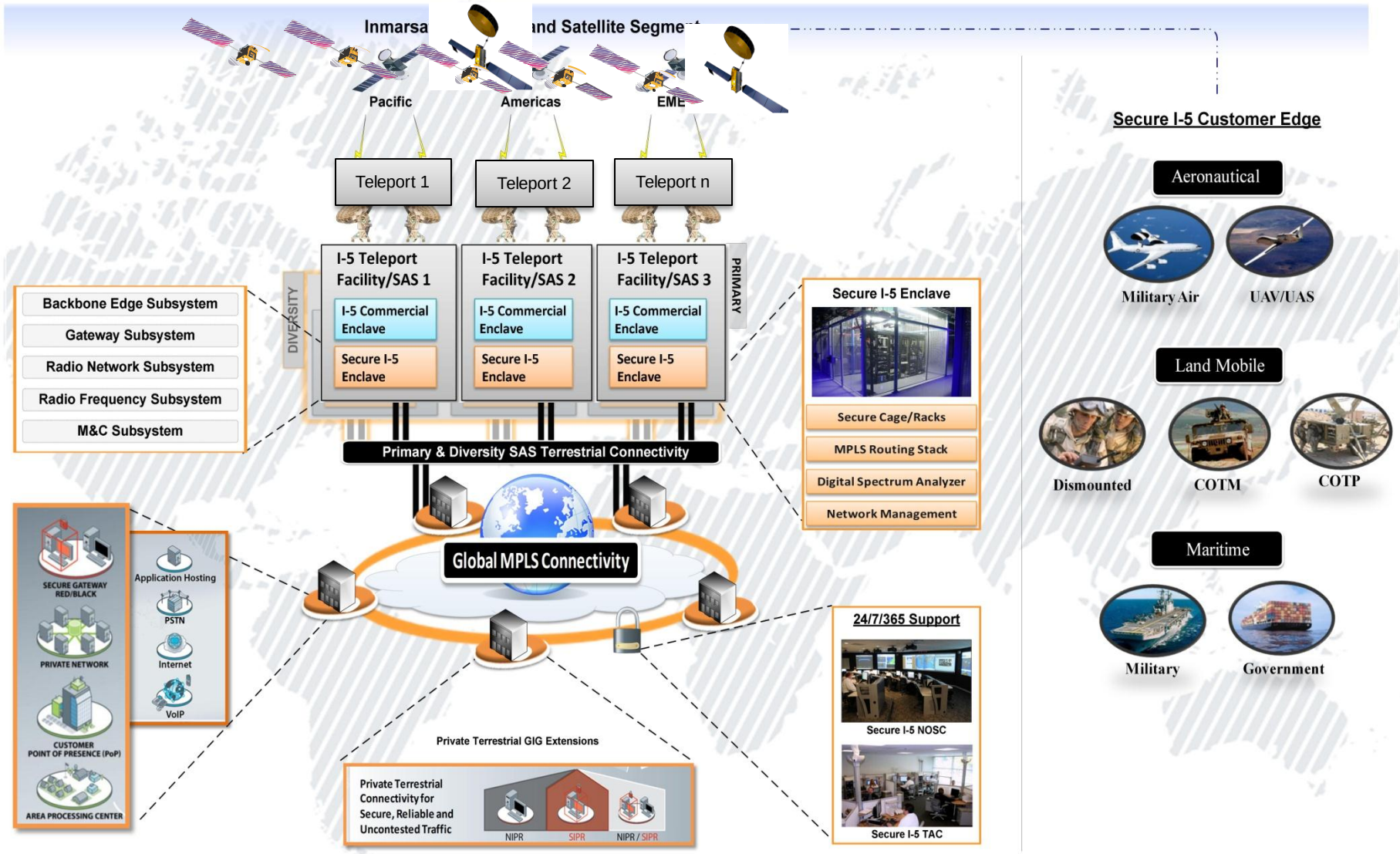
I5F3 - Pacific

I5F2 - Americas

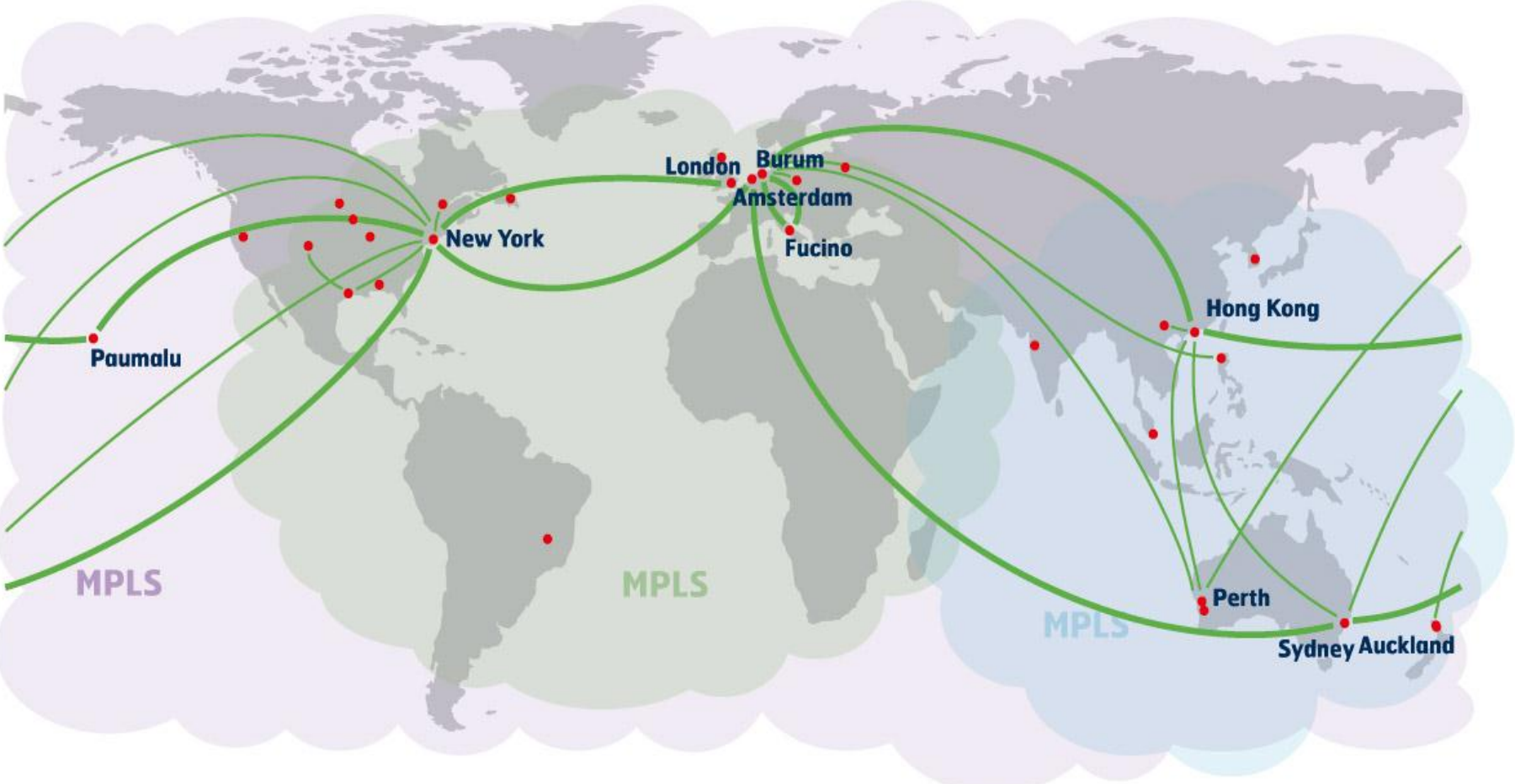
I5F1 - EMEA

Inmarsat Network Diagram

10 L-Band Satellite + Alphasat 2013 + 3 GX Ka 2014



The Inmarsat Terrestrial Network



- High Capacity Private Backbone (——)
- Multivendor MPLS Customer Connectivity (⬭)
- Main network node (●)

Meeting Your National Requirements

through a portfolio of Government Applications

Military Apps

- UAVs, Aero, Gx
- ISR packages
- COTM, HH, Aero, Navy, LM
- COTP
- Anti Piracy - Navy
- Critical Infrastructure Protection
- Border Surveillance
- Bomb Detection

Govt Security

- Police & Fire Radio Extension
- Diplomatic Service Networks
- Presidential Protection
- VIP Aircraft Communications
- Secure Applications Hosting
- Facial Recognition
- SCADA & Health Monitoring
- World-Wide Asset Tracking
- Imagery

Civil Govt

- Election Monitoring
- Emergency Distress
- Disaster Relief
- Telemedicine
- Rural Education
- Training Delivery
- Rural Payroll Systems
- Vehicle Health Monitoring
- Content Delivery Management
- Telepresence

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Capacity and Versatility *for the Future*

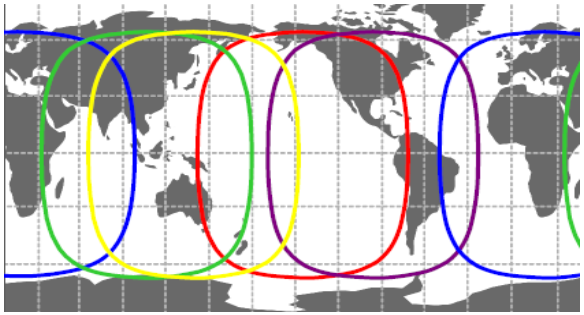
reliable

secure

global

wideband

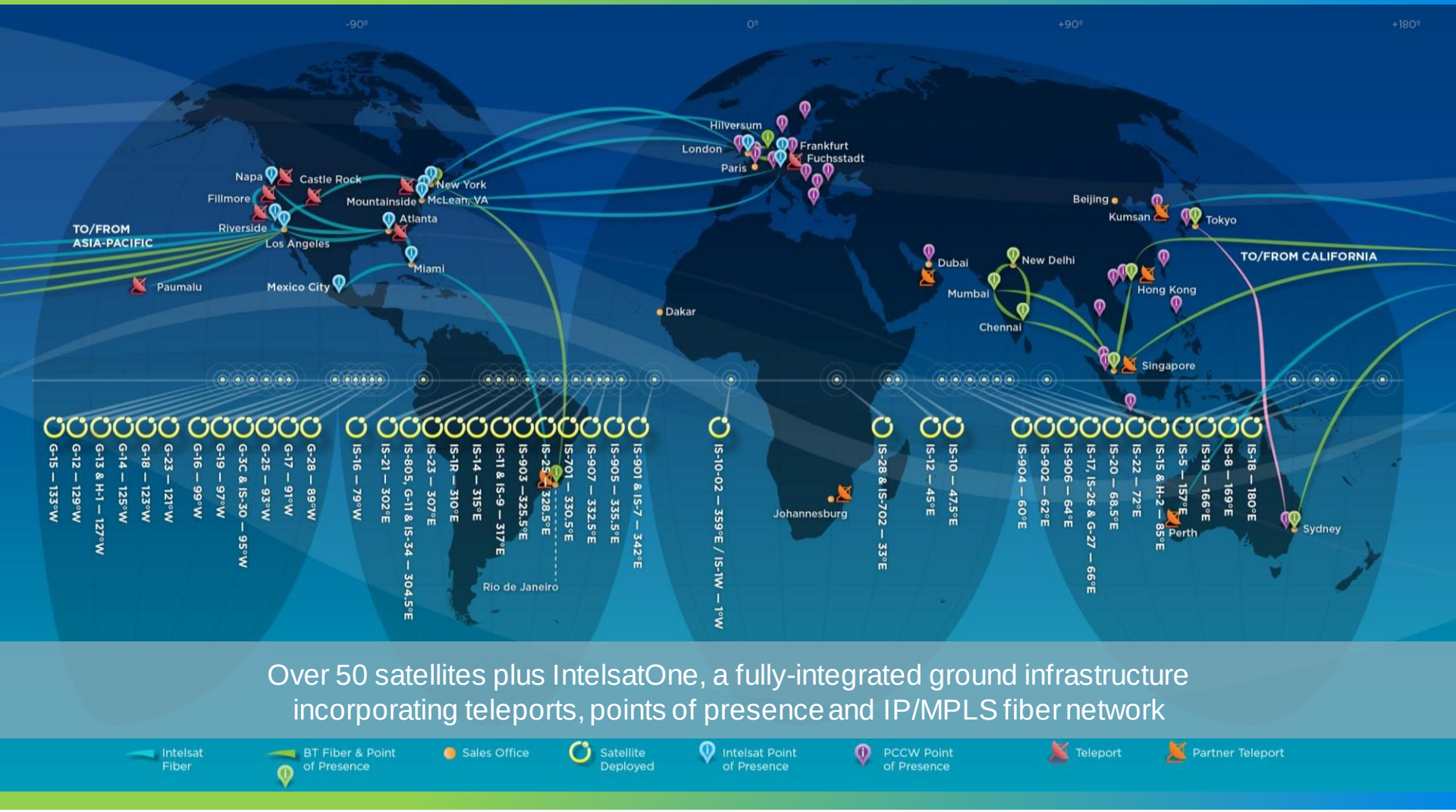
mobility



GLOBAL SATELLITE COALITION

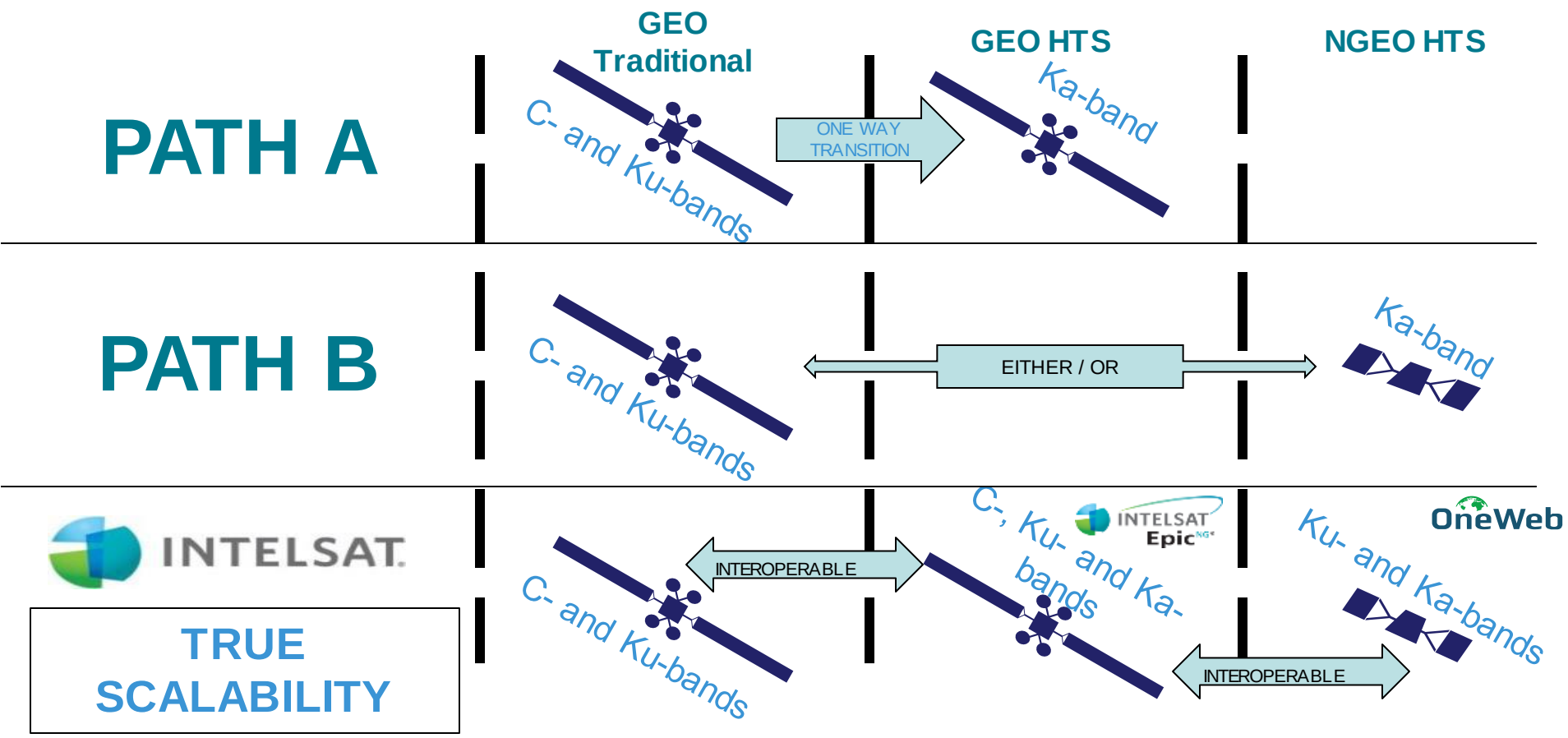
Session 2b: Intelsat EPIC Constellation

The Intelsat Globalized Network Infrastructure

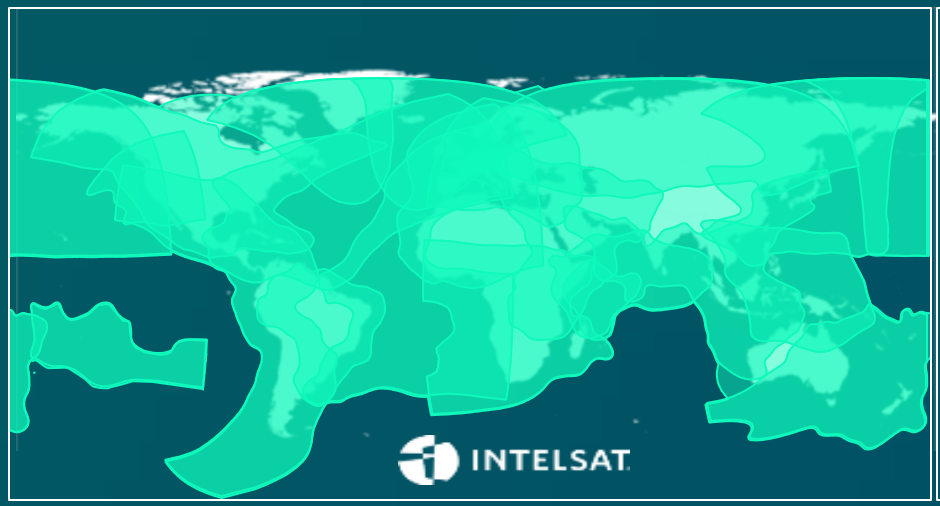


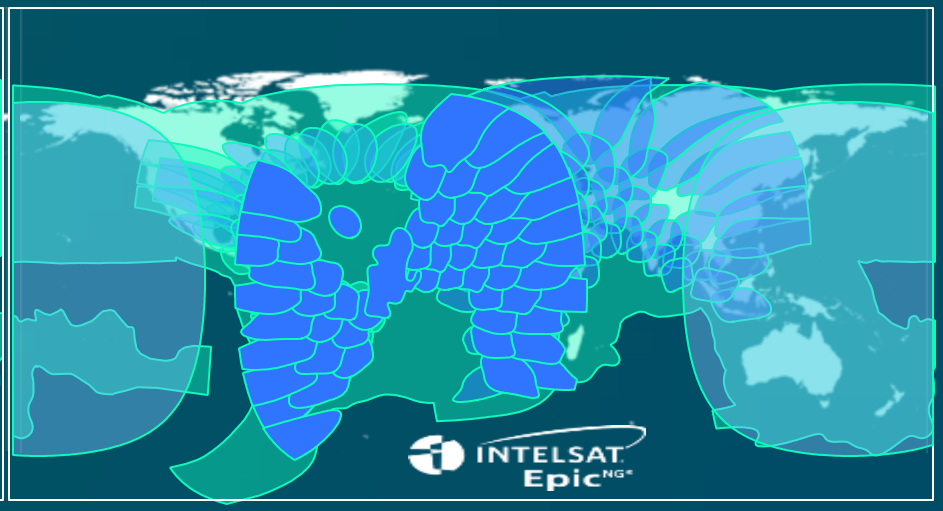
Over 50 satellites plus IntelsatOne, a fully-integrated ground infrastructure incorporating teleports, points of presence and IP/MPLS fiber network

Different Paths to High Throughput Satellites (HTS)



Building a Global C- and Ku-band Network



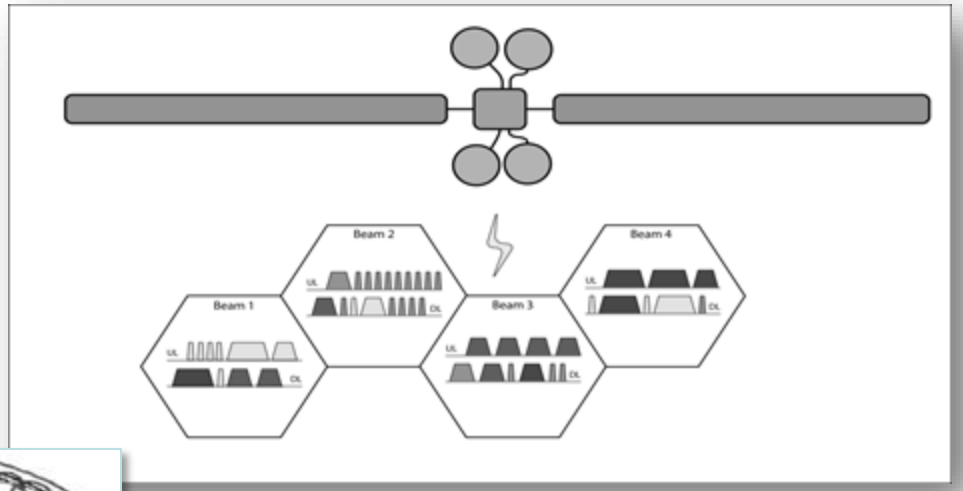


Up through 2015 | 2016-2017 | 2018 onwards

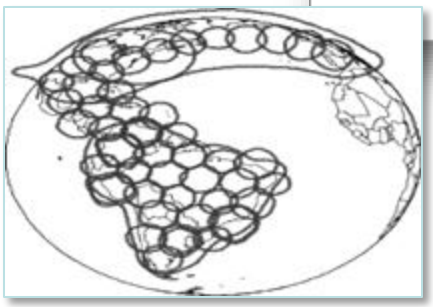
IS-21 IS-23 IS-30 IS-34 IS-29e IS-31 IS-33e IS-36 IS-32e IS-35e IS-37e IS-38 H-3e IS-39

Intelsat Epic^{NG} Features

- Satellites utilize small multi-spot uplink and downlink beams covering the desired area



- Why?
  - Frequency reuse – more bandwidth
  - Better G/T – better performance
  - Higher EIRP
  - Higher throughput



Throughput is 25-60 Gbps, or 10X that of traditional bent pipe payloads

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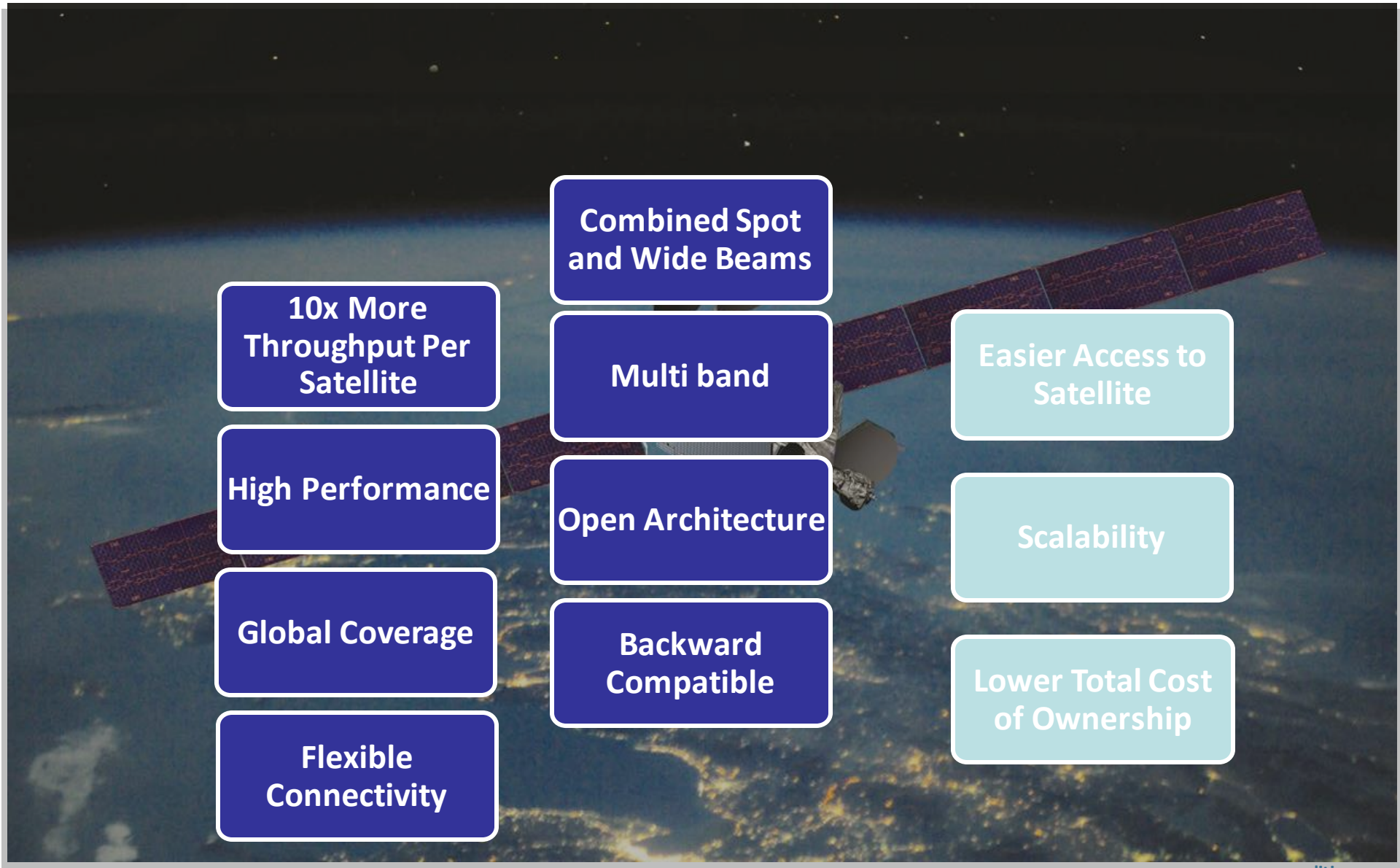
HTS Example



OneWeb
ACCESS FOR EVERYONE

Total throughput of the system:

5 terabits per second

First Fully Global, Pole-to-Pole HTS System

The OneWeb satellite constellation:

- 650 satellites (18 planes of 36 satellites)
- Low latency (<30ms round trip delay)
- Look angles > 57◦

Credit: Airbus Defence and Space

GLOBAL SATELLITE COALITION

DESIGN PHASE

LEO HTS

- Pole-to-pole coverage
- Small terminals, low latency

HTS 2.0

- Software defined payloads with flexible coverage, power and connectivity

- 2 additional HTS satellites already contracted
- OneWeb

LAUNCH AND DEPLOYMENT PHASE

HTS 1.0

- HTS spots positioned in high traffic areas
- Complements first layer, not replaces it
- Provides depth of coverage

- 5 HTS satellites

COMPLETED

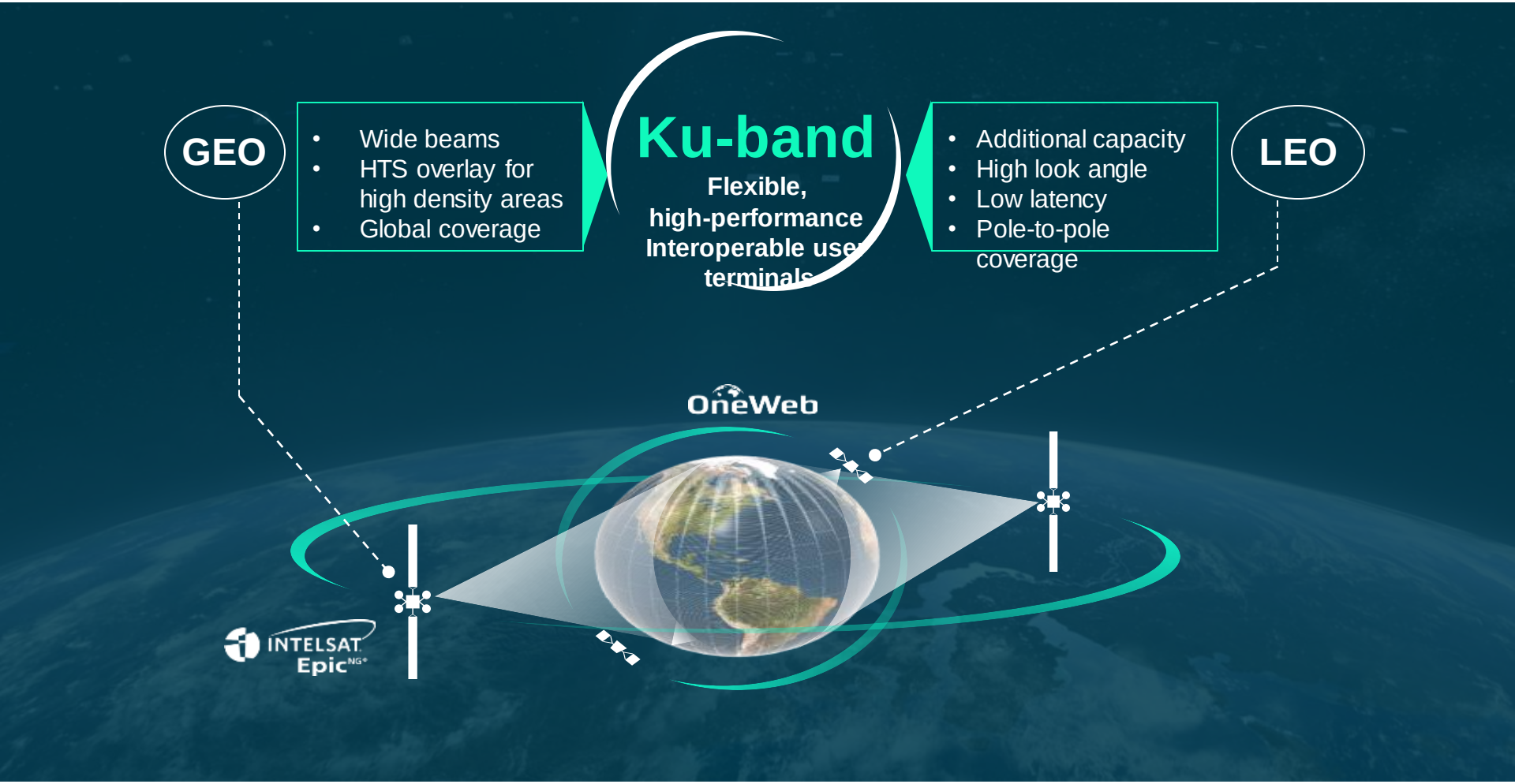
WIDEBEAM SATELLITES

- Uniform quasi-global coverage
- Base layer of the network
- Provides breadth of coverage

- 50+ satellites
- 7 wide beam mobility satellites
- 100% complete

Up through 2015 → 2016-2017 → 2018 onwards

Using GEO HTS & LEO Satellites



Designed with Interoperability in Mind

Interoperability triggered by:

Remote Situation

Shifting to the stronger signal based on geographic location or remote attitude

Capacity Availability

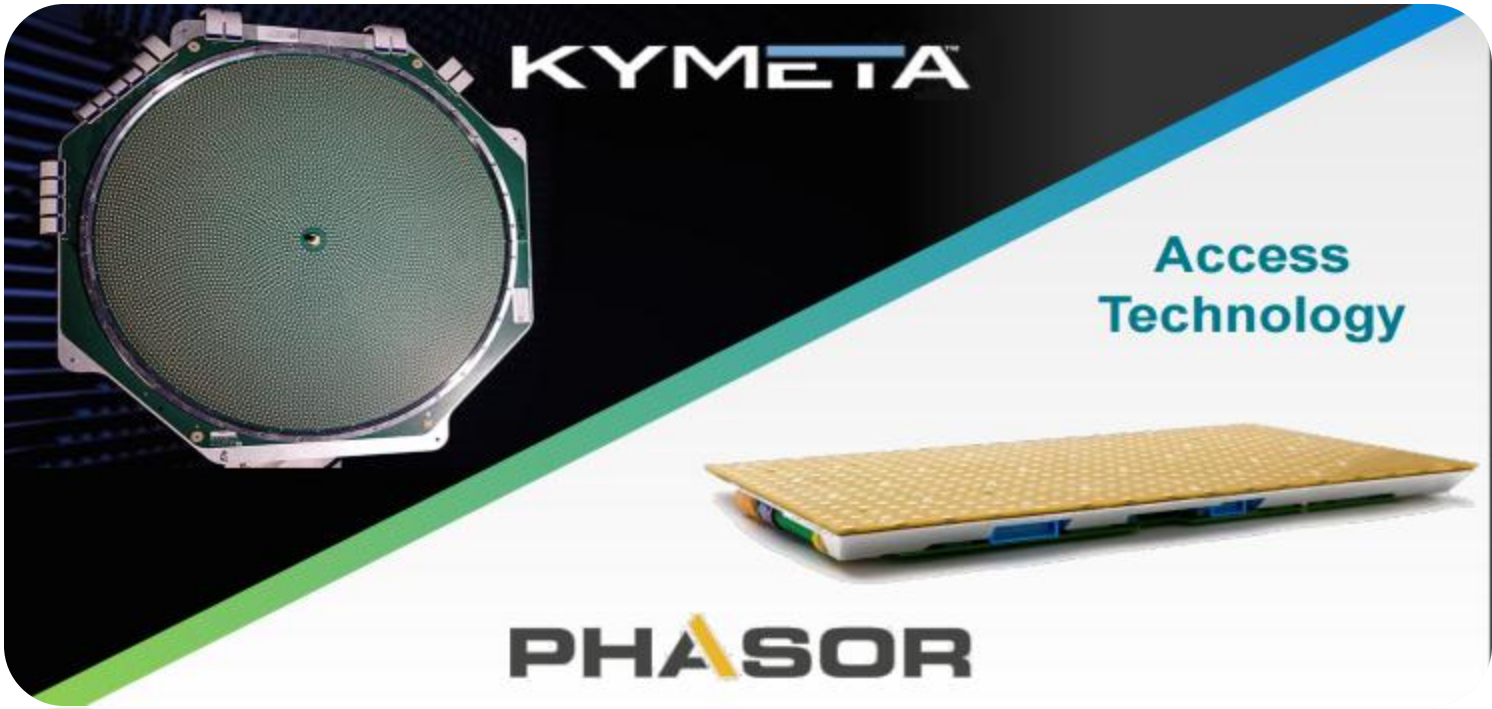
Shifting depending on local capacity availability

Application-based

Ability to route IP traffic depending on application

Innovation in Ground Technology

- Business and small jets
- Vehicles
- Hand-held devices
- IoT applications
- Sensors



Advancements in ground segment technology are enabling access to new and previously unserved segments

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The **Connected** Car

Onboard sensors with Internet connectivity

Self–driving / autonomous

Operation and maintenance, self-optimization

A component of the ‘Internet of Things’

Service based on connectivity to the ‘cloud’

“Driver centric” for increasing functions and improved safety

Increased passenger convenience and comfort

The Future

Kymeta and Intelsat solution is being designed to deliver 1TB of data per month to each car

FCC Mobility Rules in C- and Ku-bands

- FCC created Blanket Licensing Rules for Earth Stations on Vessels (ESVs), Vehicle-Mounted Earth Stations (VMESs) and for Earth Stations Aboard Aircraft (ESAAs)

Earth Station Type	Frequency Bands	FCC Rules	ITU-R Recommendation
ESV	C-band[1], Ku-band[2]	C.F.R. 47 § 25.222	ITU-R S.1587
VMES	Ku-band[2]	C.F.R. 47 § 25.226	ITU-R S.1857
ESAA	Ku-band[2]	C.F.R. 47 § 25.227	ITU-R M.1643

Note 1. **The following C-band frequencies are covered: 3700-4200 MHz (space-to-Earth) and 5925-6425 MHz (Earth-to-space).**

Note 2. **The following Ku-band frequencies are covered: 10.95-11.2 GHz (space-to-Earth), 11.45-11.7 GHz (space-to-Earth), 11.7-12.2 GHz (space-to-Earth) and 14.0-14.5 GHz (Earth-to-space).**

- CITEL PCC.II Recommendation under development (CCP.II-RADIO/doc. 4265/17 rev.2)

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The Way Forward

Accessible and Efficient High Speed Connectivity

INTELSAT

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Session 4c: Viasat's 3rd Generation

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Viasat: Trusted Around The World

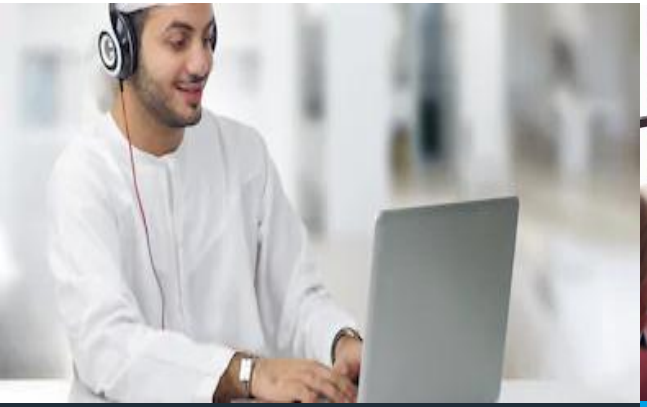
1986 year founded	5,200+ employees	28 offices around the globe	5 satellites in orbit
~700k home internet subscribers	60 Million devices on airplanes connected by satellite annually	$1.6B in annual sales*	$3.0B broadband investment

* FY18, ended March 31, 2018

Countries Viasat currently serves

Viasat

Satellite Broadband Applications Powered By Entire Ka-Band



Unlimited home internet plans provide unlimited possibilities

Business internet and Wi-Fi

Connecting the unconnected to affordable high-speed internet

The best Wi-Fi in the sky gives every passenger freedom to stream

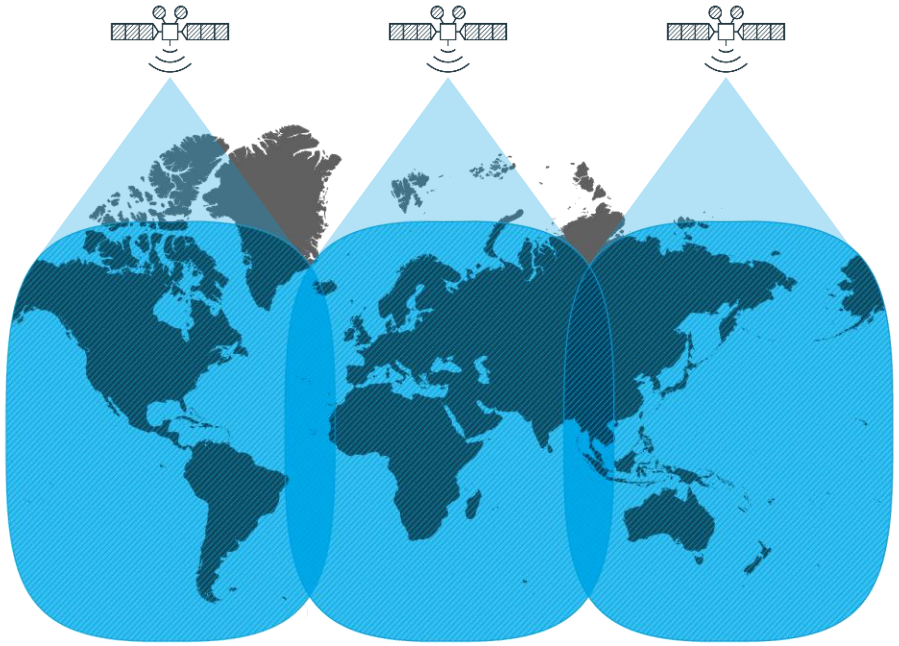
Stay productive and entertained while traveling

Fast, reliable internet for cruise ships, pleasure craft, and other vessels

Coverage Evolution with Entire Ka-Band

ViaSat-1 & 2

ViaSat-3



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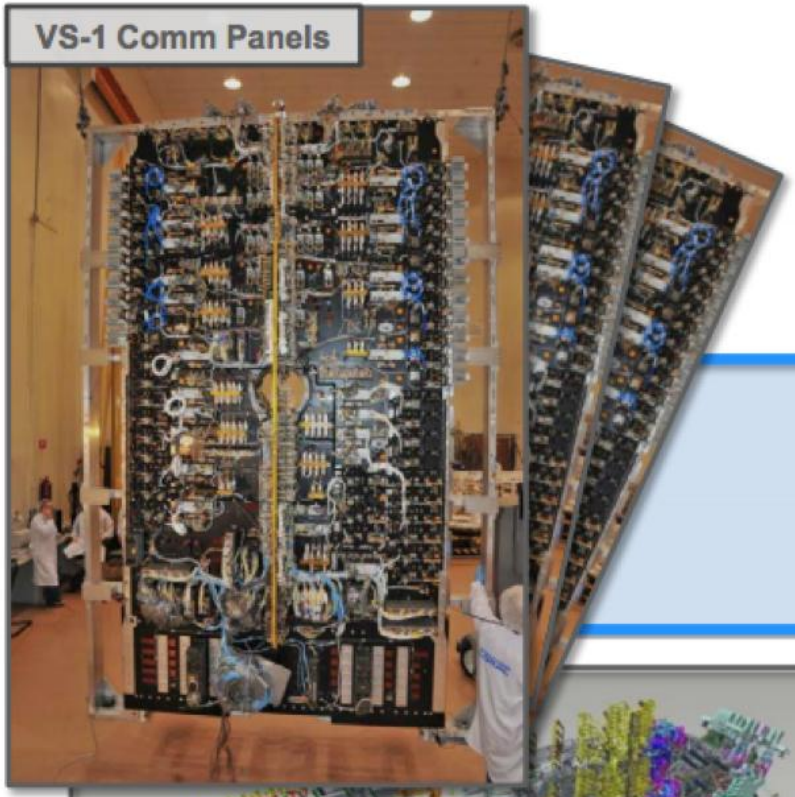
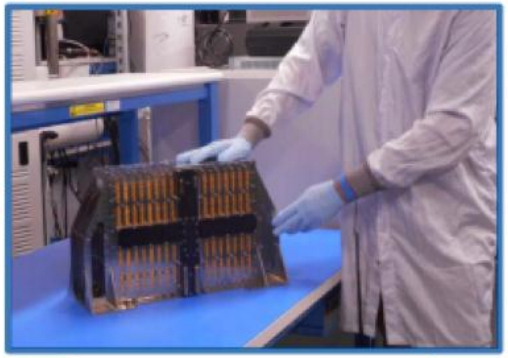
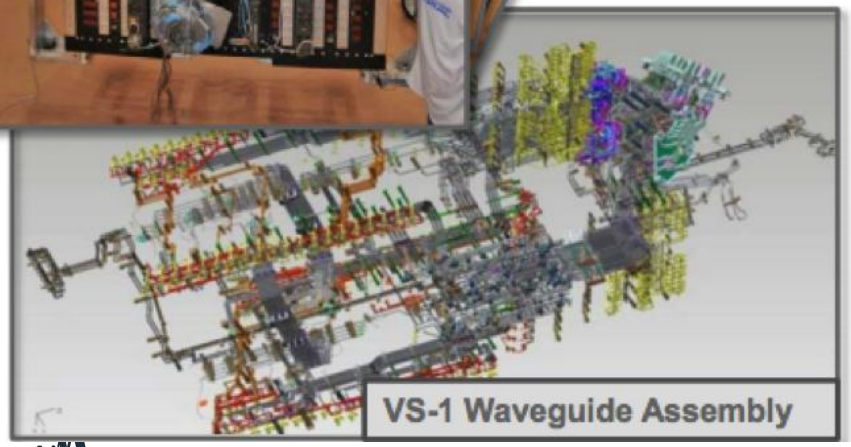
Ka-Band Broadband Satellite Evolution





VS-3 Comm Module



Each ViaSat-3 has ~10x the bandwidth of ViaSat-1

Ka-Band Gateway and Capacity Evolution

ViaSat-1

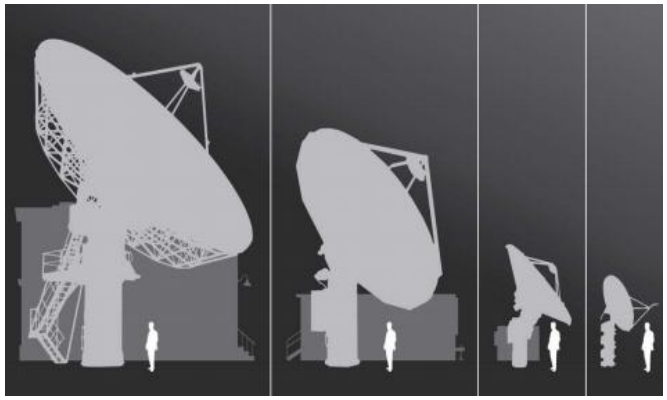
- At least 140 Gbit/s of total capacity
- 17 sites
- 7.3 m antennas
- Mostly located outside urban areas

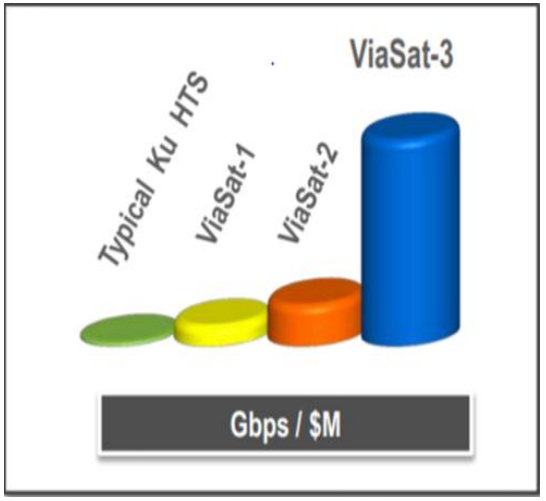
ViaSat-2

- Max potential capacity of approx. 260 Gbit/s
- More than 40 sites
- 4.1 m antennas
- Many located in urban/suburban areas to access cost-effective fiber

ViaSat-3

- 1+ Tbps capacity
- Hundreds of sites
- Even smaller antennas
- Many located in urban/suburban areas to access cost-effective fiber





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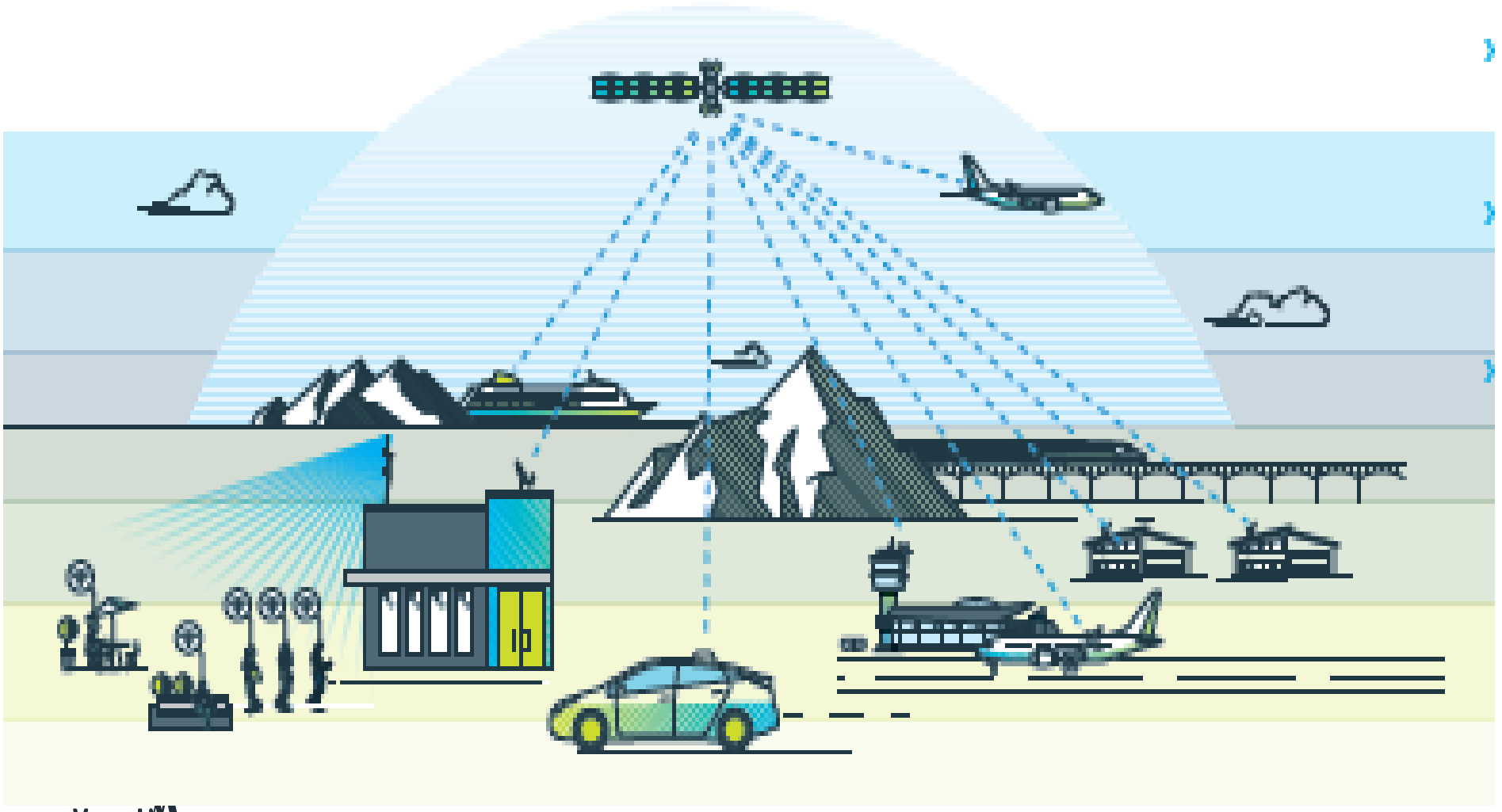
Ka-Band Service Evolution: Connecting Everyone Everywhere



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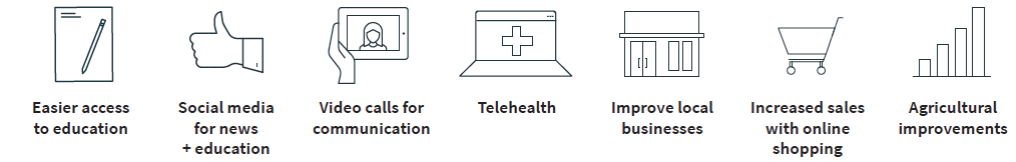
Ka-Band Satellite-Powered Community Wi-Fi

- Wi-Fi hotspots powered by Ka-Band satellite serve entire communities
- Deployable in hours
- Customers use their existing phones and tablets
- ~2,000 communities and 850,000 people covered in the first year
- Adding 400-500 communities per month
- Expanding around the world



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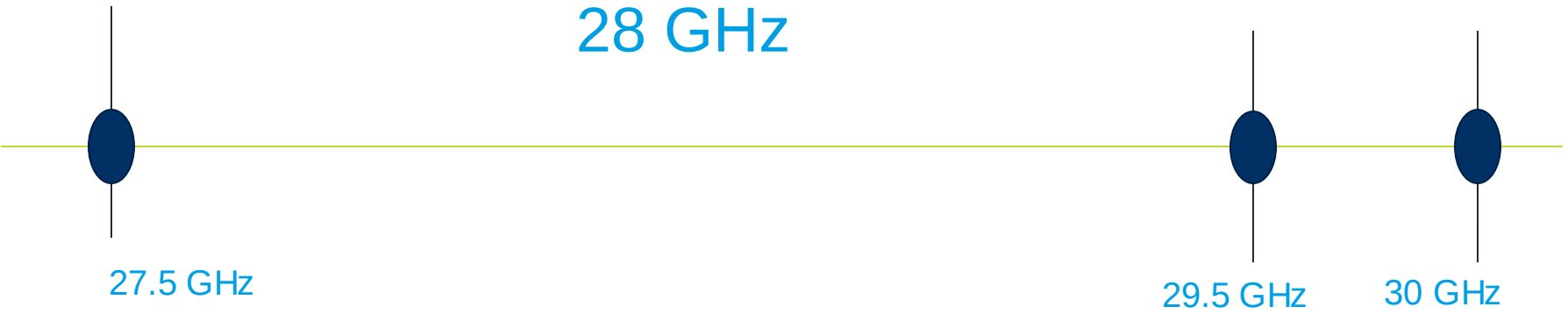
Spectrum is Key

2.5 GHz of Ka-Band spectrum used today to deliver satellite broadband



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Continued Access to the 28 GHz Band is Critical

- Today's satellite broadband connectivity enabled by access to full 28 GHz band
  - Serving millions of individuals and businesses no matter where located -urban, suburban & rural
  - Providing Wi-Fi connectivity to people and devices on thousands of airplanes globally

- Continued access to the 28 GHz band is the only way to
  - Meet exponentially growing customer demands
  - Enable new applications like Community and Urban Wi-Fi to connect many millions in the next 5 years

- Extensive satellite use is why international community decided not to consider 28 GHz for 5G in 2015

- New 5G systems not designed to be compatible with existing satellite uses of 28 GHz

- 5G can be readily accommodated in portion of 33+ GHz of other spectrum identified for 5G at WRC-15, plus low and mid band spectrum being made available around the world

- Essential that current satellite access to 28 GHz be maintained throughout the world to bridge the digital divide and meet the mobile needs of individuals, businesses and governments

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AI 1.13: Continued Satellite Access to the Q/V Band Closes the Digital Divide

- Satellite broadband demand high and services critical for closing the digital divide
  - Satellite broadband demand—residential, enterprise, mobile and government
  - New broadband networks being developed for Q/V-band in response
  - 5G systems as proposed are not compatible with satellite usage
    - 5G demands protection criteria I/N = -6 dB all the time
      - Not reasonable for a mobile system
    - 5G opposes any limitations that would facilitate coexistence
      - E.g., base station power limit, down tilt
        - Such limits are being required in other bands 5G seeks to use

- Satellite needs Q/V band access for both gateways and user terminals
  - 5 GHz in each direction for gateways
  - 2 GHz in each direction for user terminals

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AI 1.13: Continued Satellite Access to the Q/V Band Closes the Digital Divide

- Viasat studied 37.5-42.5 GHz band (TG 5-1/313)
  - Addresses potential 5G coexistence with satellite earth stations operating with nearby gateway earth stations and user terminals
  - Results show that 5G and satellite gateways can exist in close proximity to each other as long as actual 5G operations *are limited to the 5G parameters specified by WP 5D in the ITU process*
    - Power levels for base station and user equipment
    - Base station antenna pointing (down tilt)
    - Deployment scenario
    - Time division duplex (TDD) activity factor
    - Network loading factor
  - Results also show why satellite user terminals need separate spectrum in which they can operate unimpaired by 5G operations
- Any consideration of 5G should take into account the need to accommodate Q/V band satellite uses as well

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AI1.6: Non-GSO Regulatory Certainty in the Q/V Band

- Article 22.2 is in force today
  - Non-GSO shall not cause unacceptable interference to nor claim protection from GSO systems

- New proposals have been made to specify protection criteria for GSO systems
  - Per non-GSO system limit of 3% increase in unavailability for GSO networks (single-entry)
  - 10% aggregate non-GSO limit (all non-GSO systems) increase in unavailability for GSO networks
  - But more than 3 non-GSO FSS systems may operate at the maximum levels on a co-frequency basis
    - 12 non-GSO systems proposed to serve the United States alone
    - Many dozens filed at the ITU

- Need an enforcement mechanism for the aggregate limits to protect the GSO
  - Only an non-binding consultation meeting process has been proposed

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AI1.6: Non-GSO Regulatory Certainty in the Q/V Band

- The "consultation meeting" approach will not be an effective remedy for any GSO system that suffers interference.
  - There would be no mandatory means of containing non-GSO emissions within the aggregate limit once more than three non-GSO systems deploy
  - The only way aggregate emissions from all of those systems actually would be reduced would be with the mutual agreement of all of the operators of the non-GSO systems

- Absent those competitors reaching such an agreement, the aggregate emissions of the multiple non-GSO systems could well exceed the aggregate 10% limit, resulting in an impermissible level of harm to GSO systems
  - Notably, the BR would have no active role is this process

- Unless and until a suitable mechanism is developed and implemented by the BR and the licensing administrations of each non-GSO system, No. 22.2 should not be changed

- Otherwise, GSO networks would bear the operational and commercial risk and uncertainty associated with changing the current Radio Regulations in the favor on non-GSO systems.

Viasat

Viasat

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Satellite

Beyond the reach of other technologies

Next Session 3:
NGSO Constellations