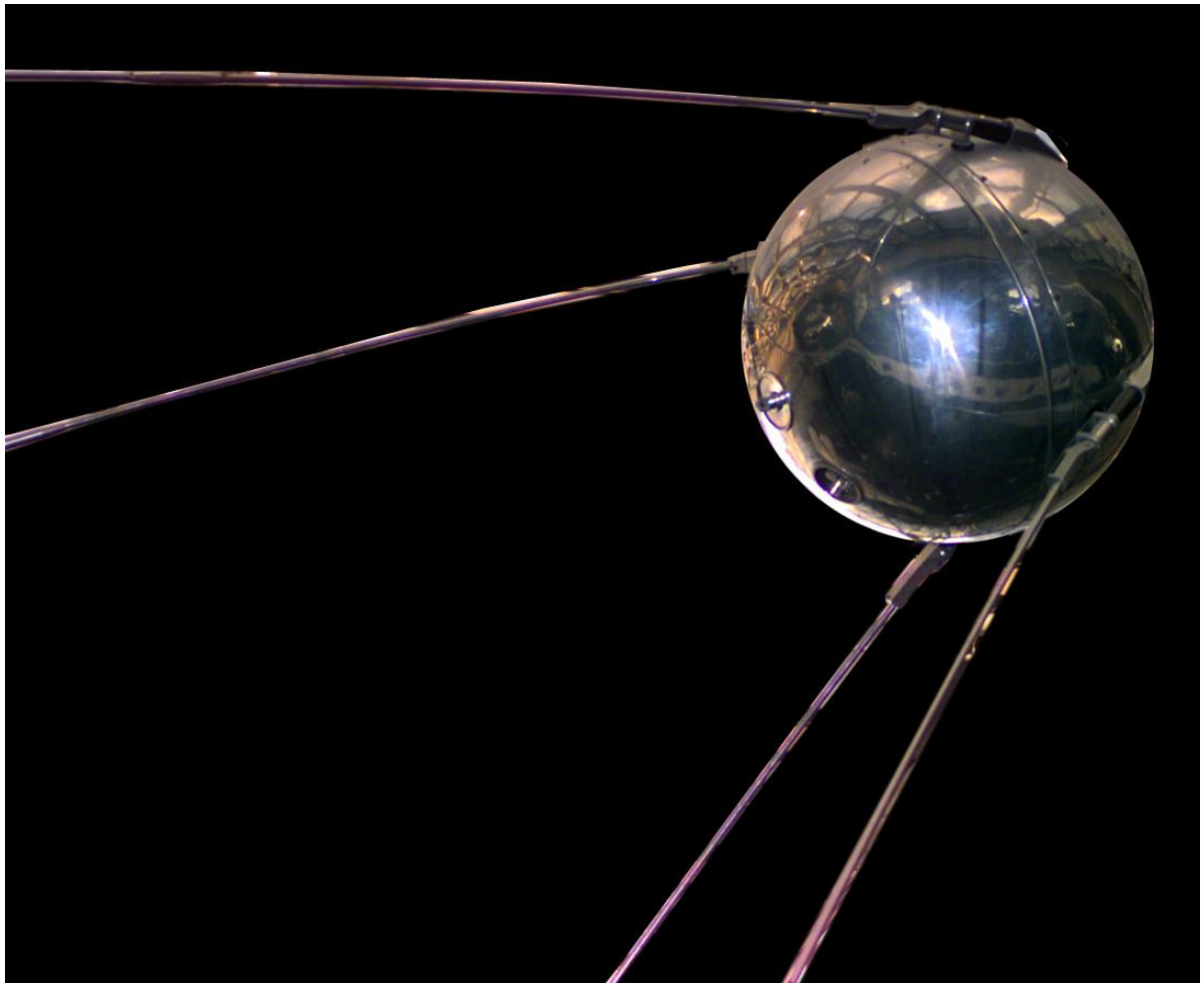
# 6th Appleton Space Conference

## Broadband Mobility via Satellite
## –
## A Technology Revolution

**Marcus Vilaça, Chief Scientist**



Satellites have come a long way since the launch of Sputnik in 1957.

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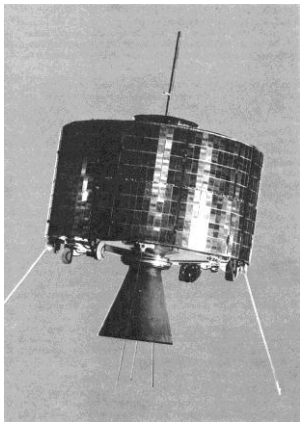
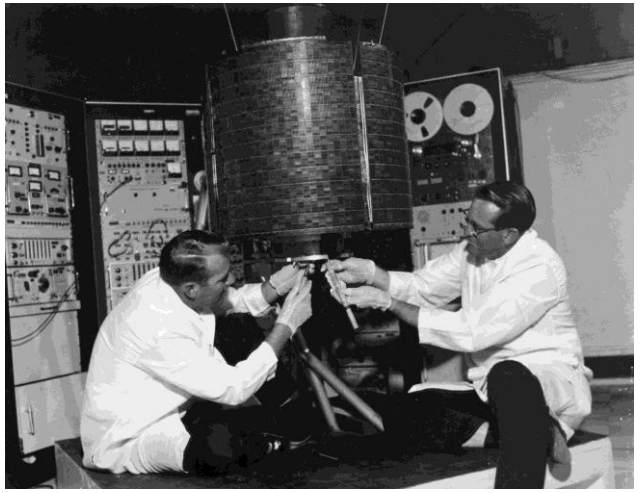
# The pioneers

- Geo stationary (Geo) communications satellites started life with the Syncom series, with Syncom 2 being launched in October 1963 (Syncom 1 had been lost in the launch a few months earlier).



- In April 1965 Intelsat 1 is launched, marking the beginning of commercial satellite communications.



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# A transforming industry

- The 70's saw a rapid proliferation of C Band Geo systems.
  - Global (Intersputnik), regional (Eutelsat) and national (Telesat).
  - Mostly used to provide trunk capacity, like transatlantic links.
  - Inmarsat created in 1979
- During the 80's the growth continued, taking satellites from the science pages to day-to-day experience.
  - Very Small Aperture Terminals (VSAT).
  - TV broadcast.
- The 90's and 00's saw the explosion of Ku band TV broadcast and low data rate mobile satellite systems.
  - Sky, DirecTV, Echostar,…
  - ICO, Iridium, Globalstar, …
- 2010's – the rise of Ka band and broadband systems
  - Wildblue, Viasat, Jupiter, Avanti…

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# A parallel path – Satellite mobility via Inmarsat

- Created in 1979 as an IGO.
- First generation services using leased satellite capacity.
  - Inmarsat A maritime terminal (analog, voice, telex and fax).
- Inmarsat 2 – launched in the early 90's.
  - Inmarsat B (maritime), M (land) and Aero (aeronautical).
    - Digital, voice, fax and data at 9.6 kbps
- Inmarsat 3 – launched in the late 90's
  - Inmarsat Fleet (maritime), GAN (land) and Swift (aeronautical)
    - Voice, fax and data at 64 kbps
- Inmarsat 4 – launched in the mid 00's
  - Inmarsat FB (maritime), BGAN (land) and SB (aero)
    - Voice, fax and data at ~0.5 Mbps
- Inmarsat 5 – to be launched in 2013-14
  - Inmarsat GlobalXpress broadband satellite mobility

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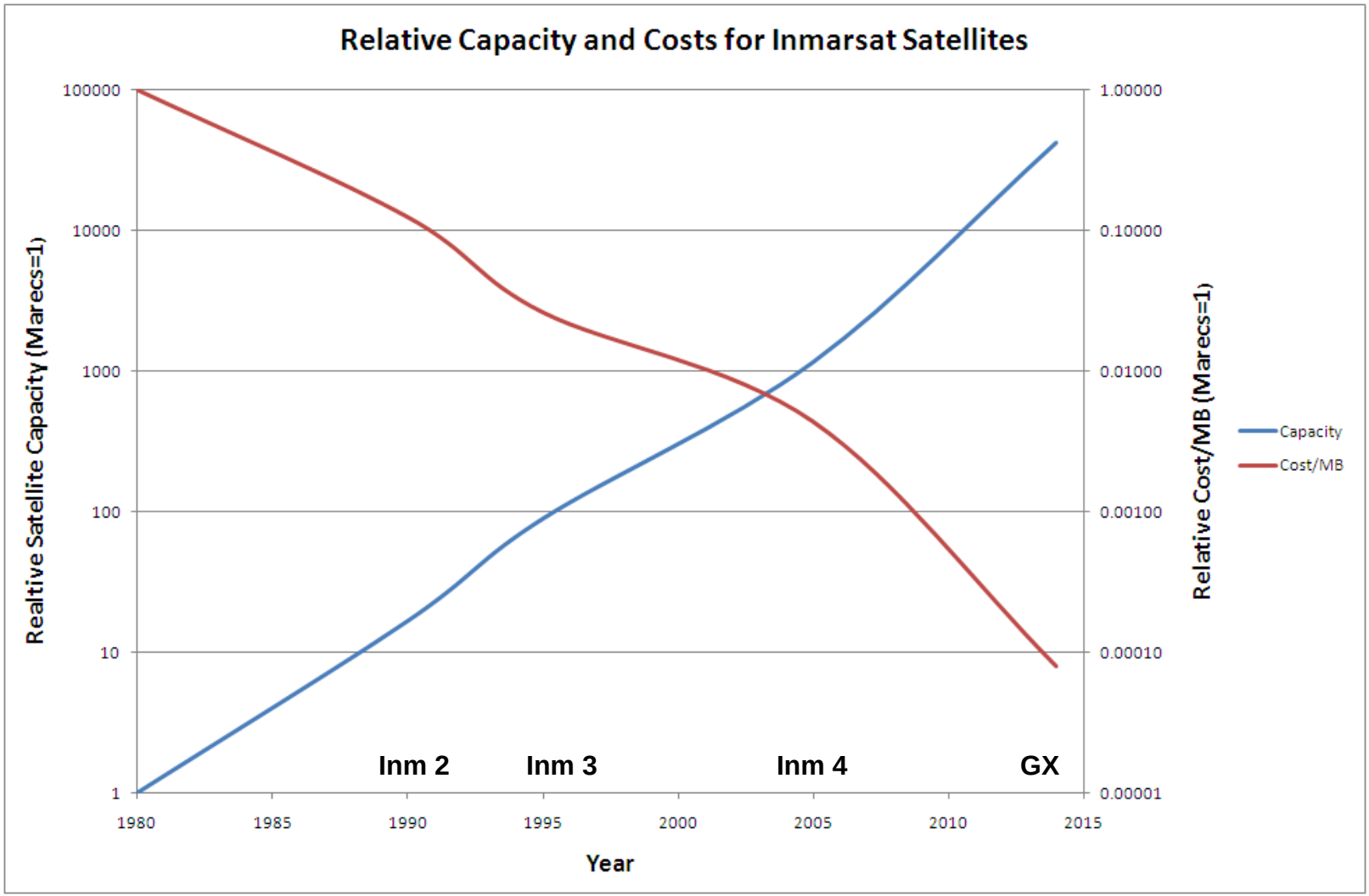
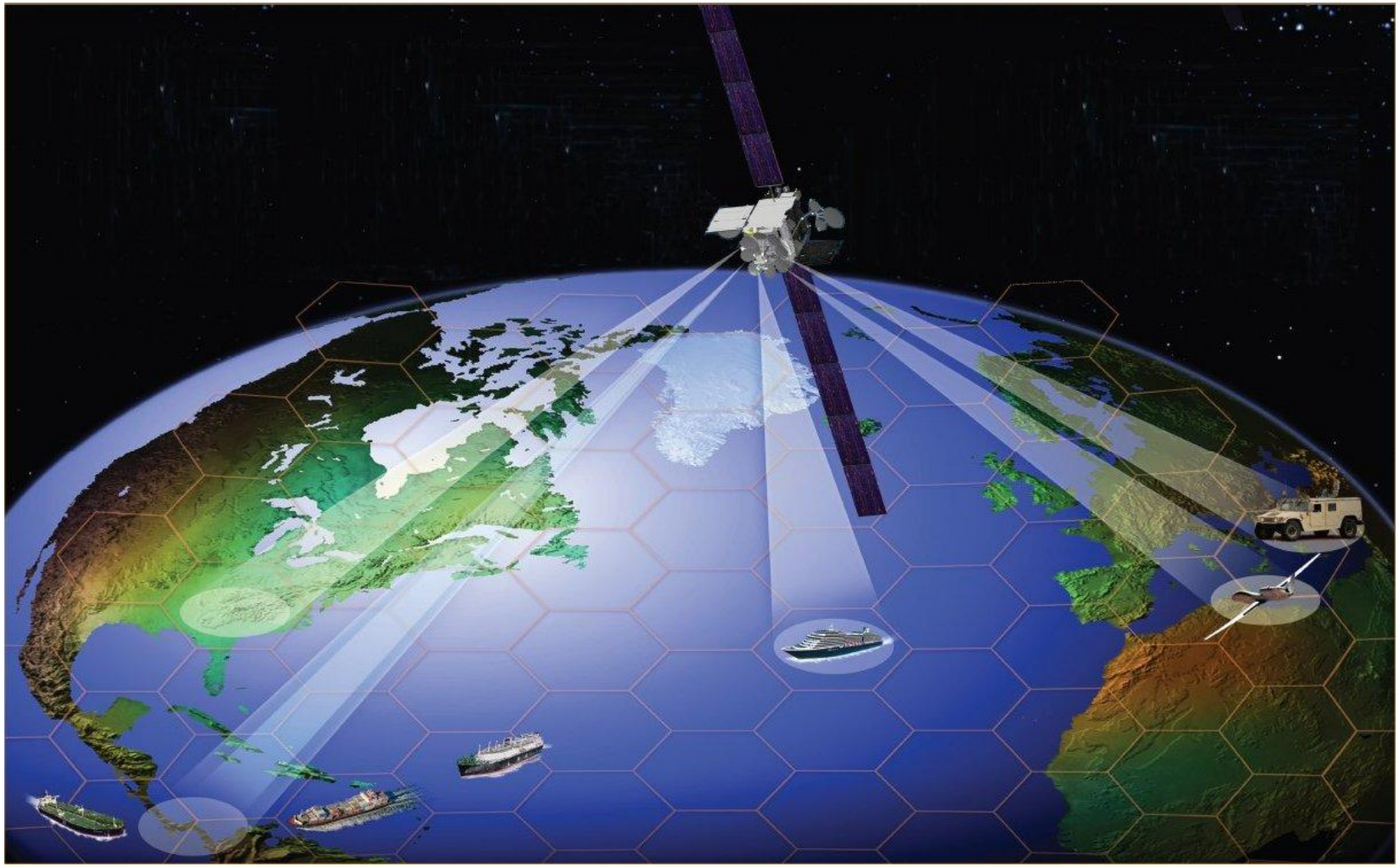
# Inmarsat system capacity and cost/MB



# GlobalXpress – global mobile broadband



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# The GX concept

- A new generation of broadband MSS
  - Major leaps forward in capacity and throughput
    - ~40 x Inmarsat-4 capacity & >60Mbps Fwrd/5Mbps Rtrn to a 60cm dish
  - Independent from L-band, but integrated as a service offering
- Global payload
  - 89 fixed beams per satellite
    - Highly flexible bent-pipe design variable power and bandwidth per beam
  - 2 x 72 x 40 MHz Channels
    - >6 Gbps aggregate throughput per satellite
- High capacity payload
  - 6 fully steerable beams per satellite
    - Traffic landed in gateway beams
  - 2 x 8 x 125 MHz transponders for commercial Ka services
    - Additional capacity on government Ka band allocations
    - ~6 Gbps aggregate throughput per satellite

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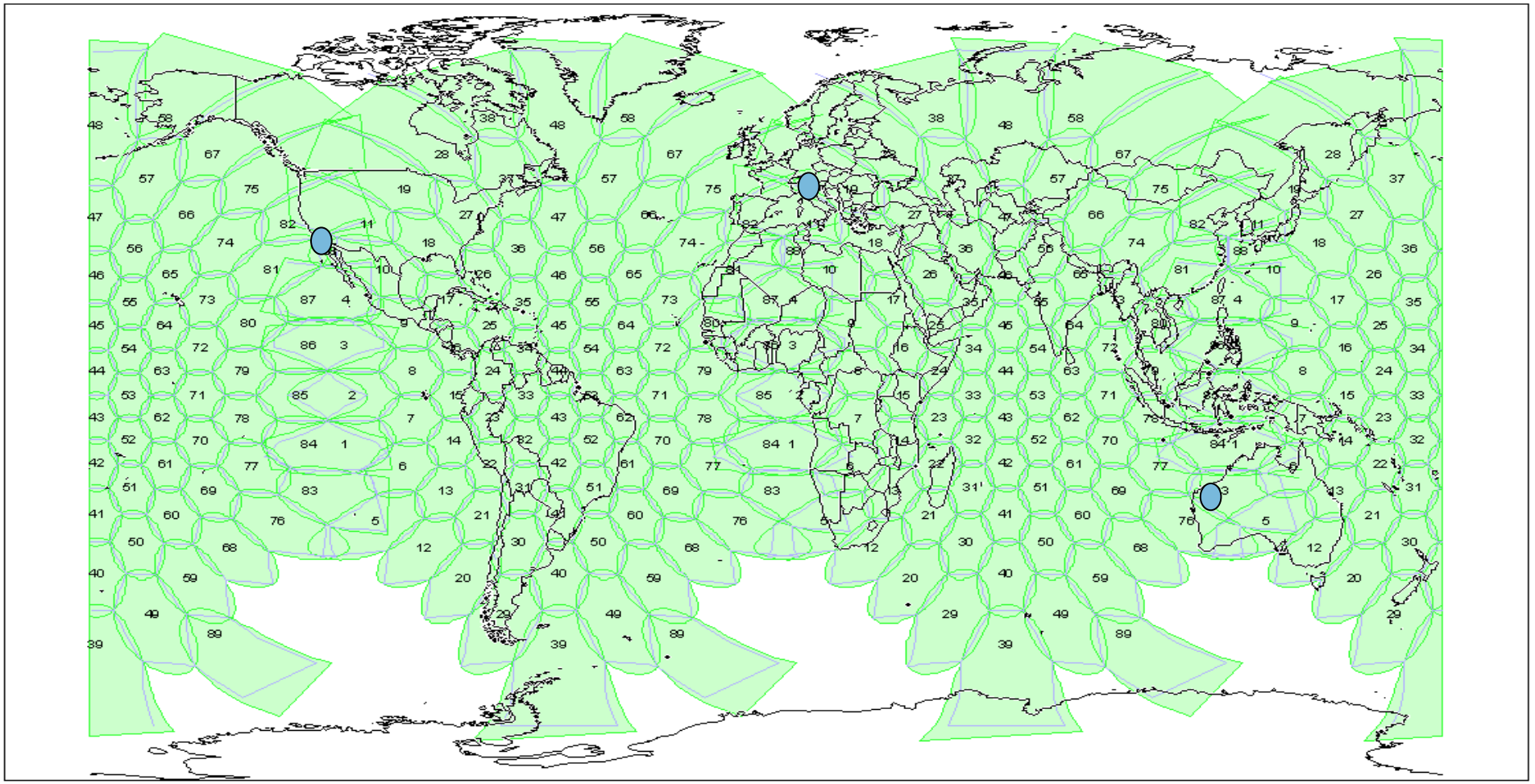
# Global coverage



Indicative gateway locations

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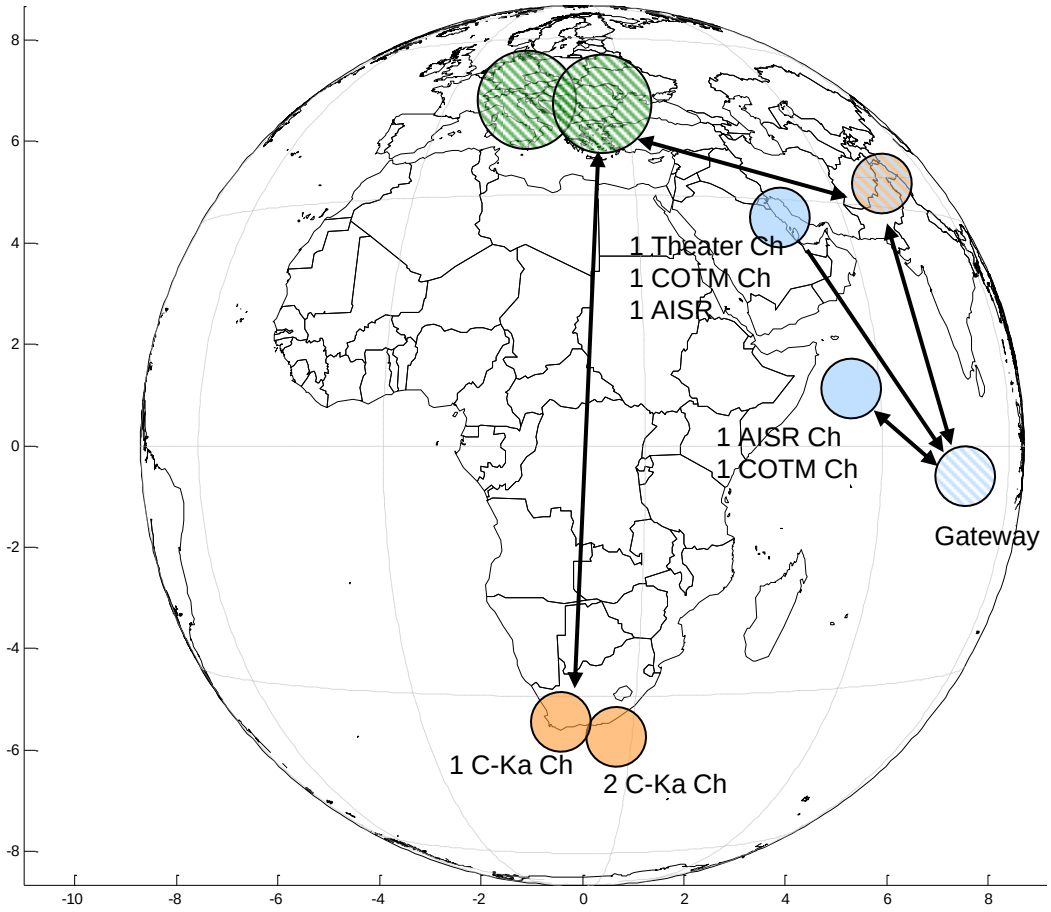
# High capacity coverage




Commercial Ka High-Capacity Overlay

Government Ka

Commercial Gateway

Dual Pol

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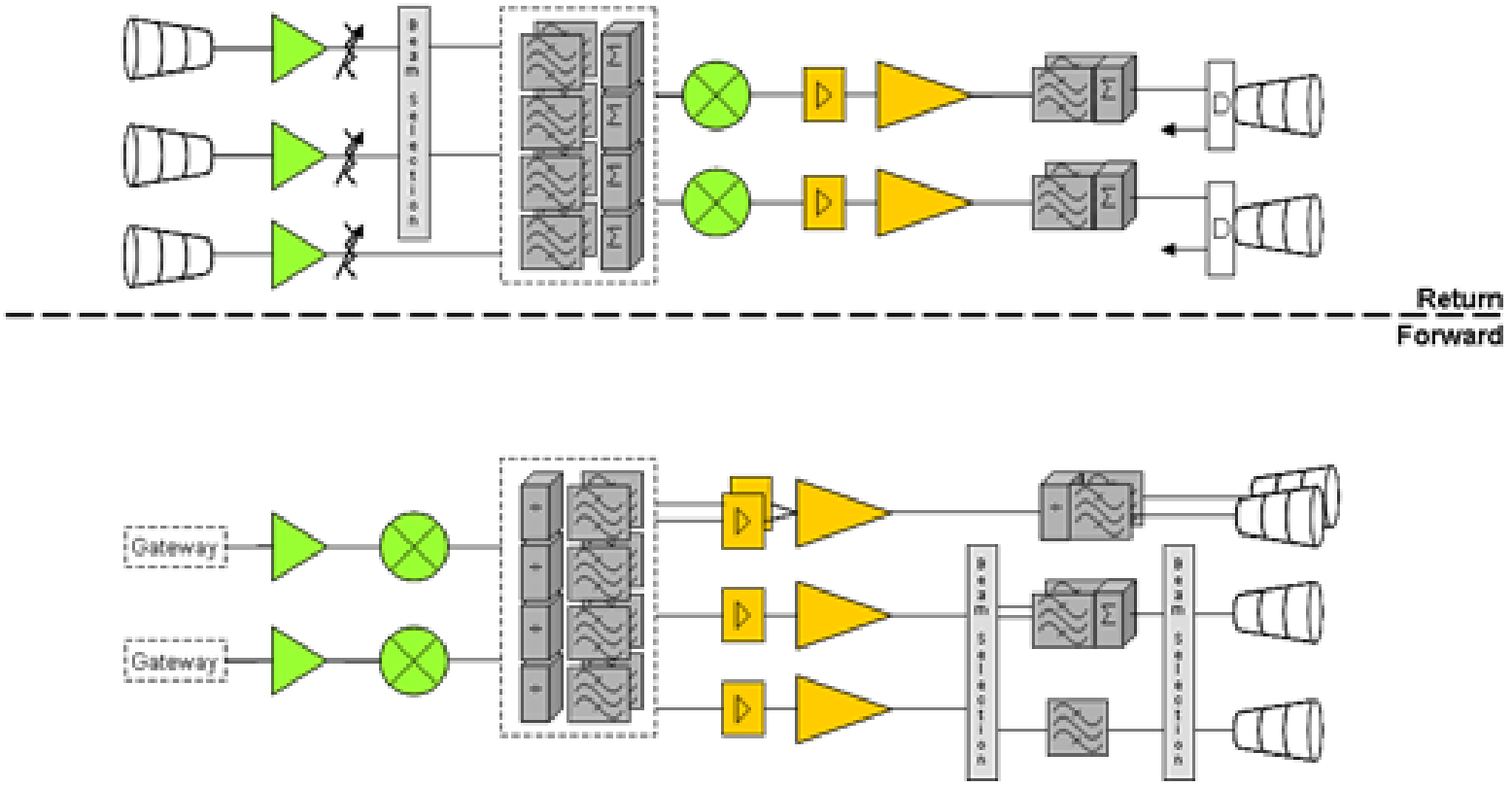
# Conventional, high heritage architecture

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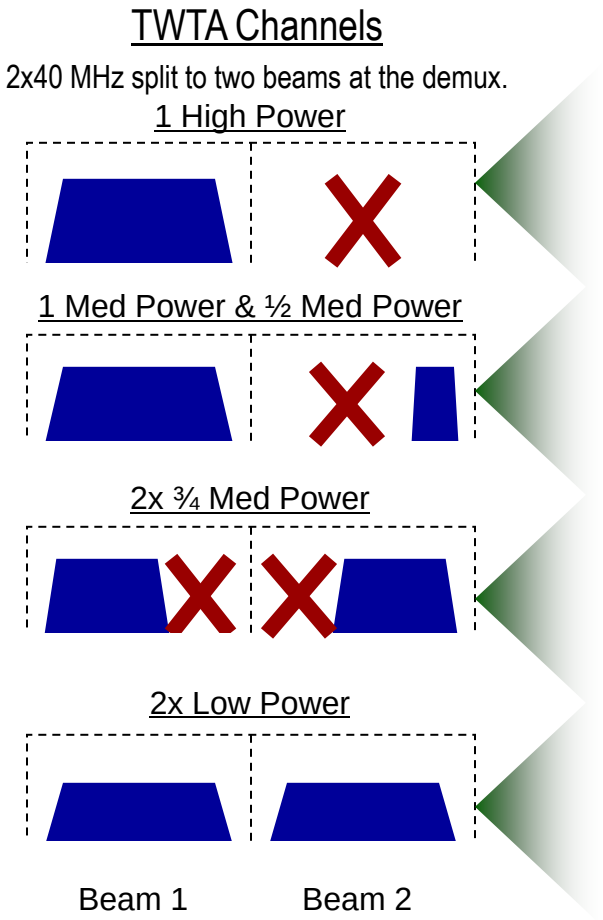
# Flexible power and bandwidth allocation




## Single High-Capacity Beam

**All TWTA power is allocated to channel in single beam. Other beam is off**

## Large and Small Market

**TWTA power allocated unequally among pair of beams. Allocation determined by market demand**

## Two Equal Markets

**TWTA power is allocated equally among pair of beams at specified EIRP density**

## Two Equal Markets

**TWTA power is allocated equally among pair of beams below specified EIRP density**

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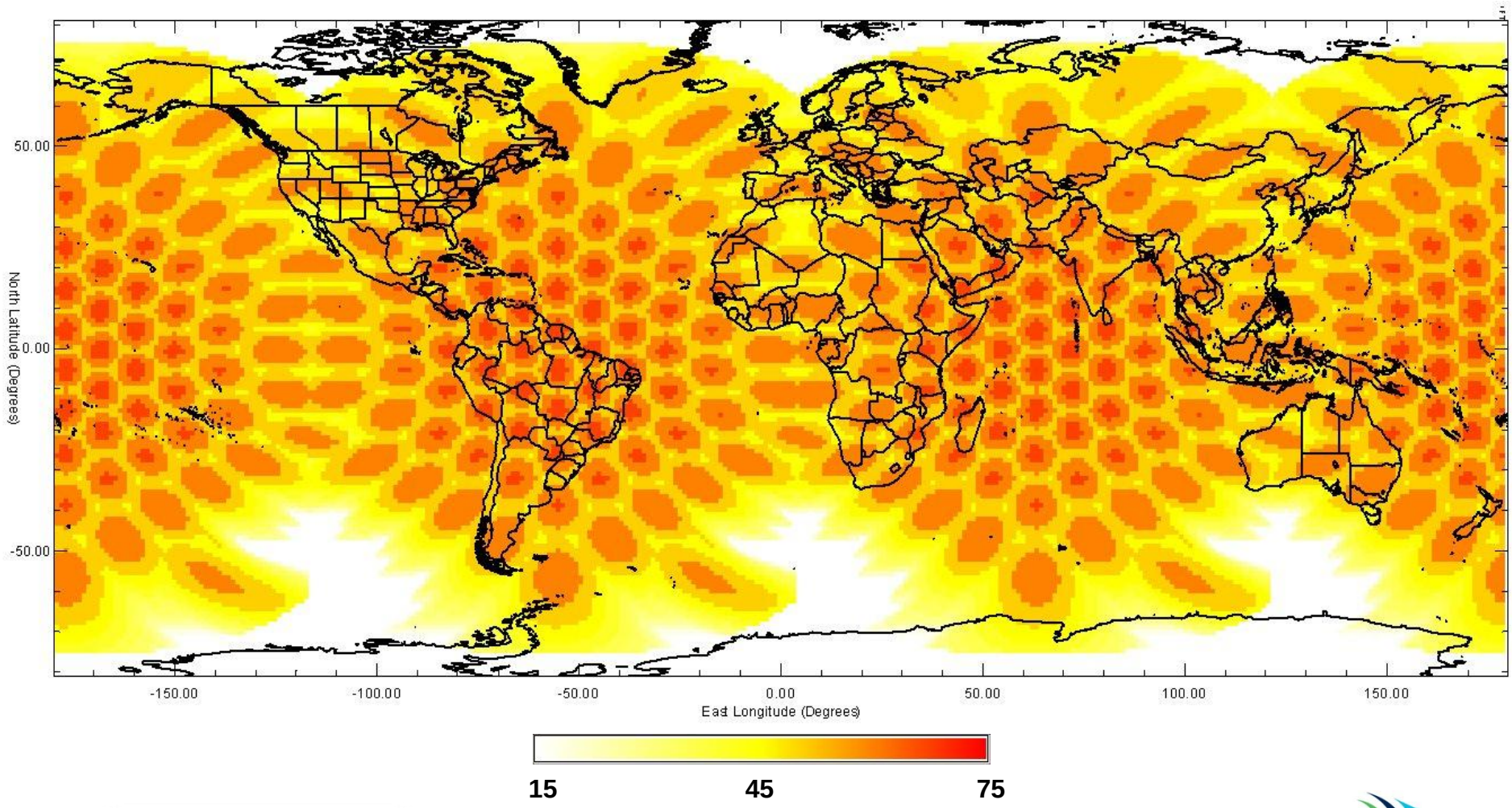
# 60 cm dish forward clear sky data rates (Mbps)

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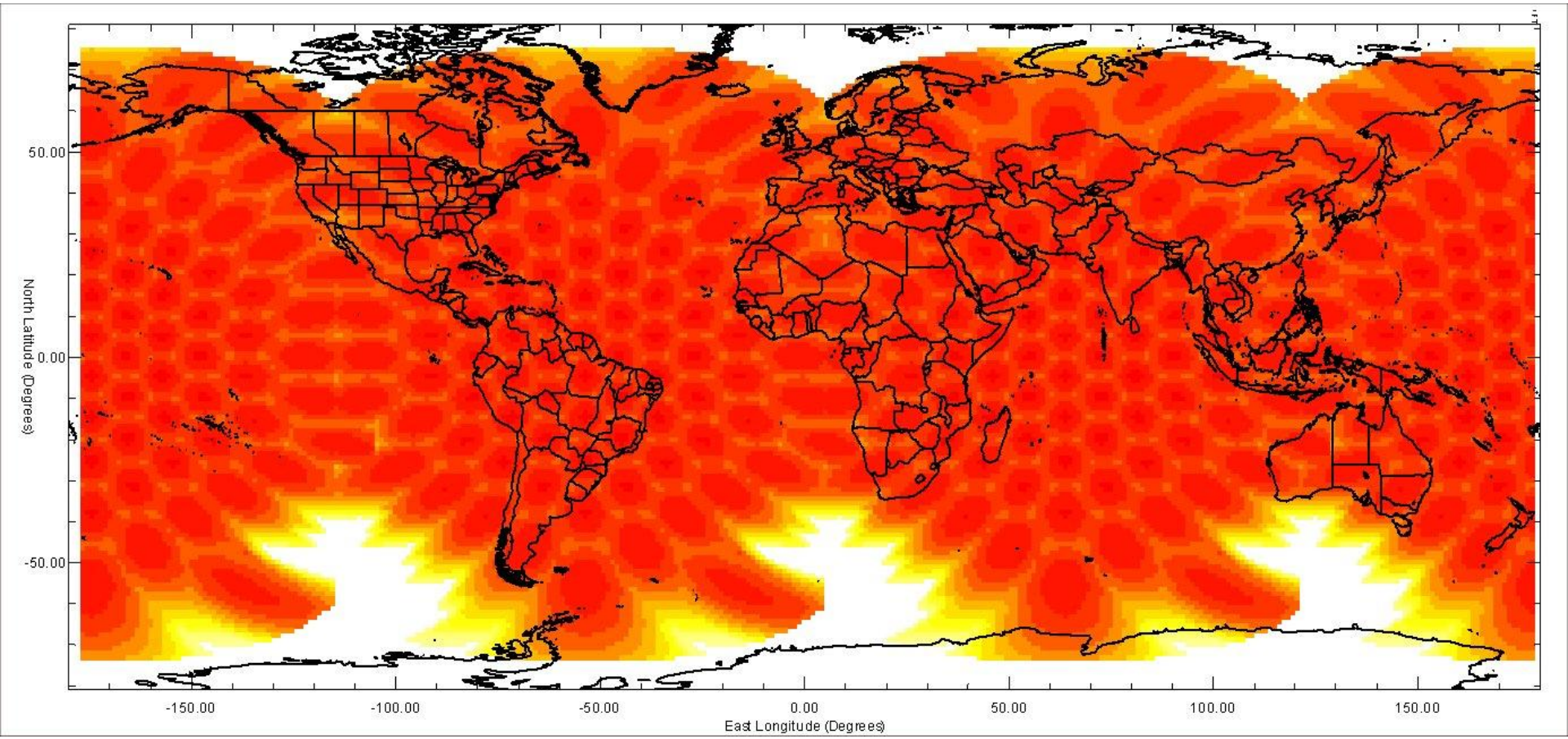
# 60 cm dish return clear sky data rates (Mbps)




0 2.5 5

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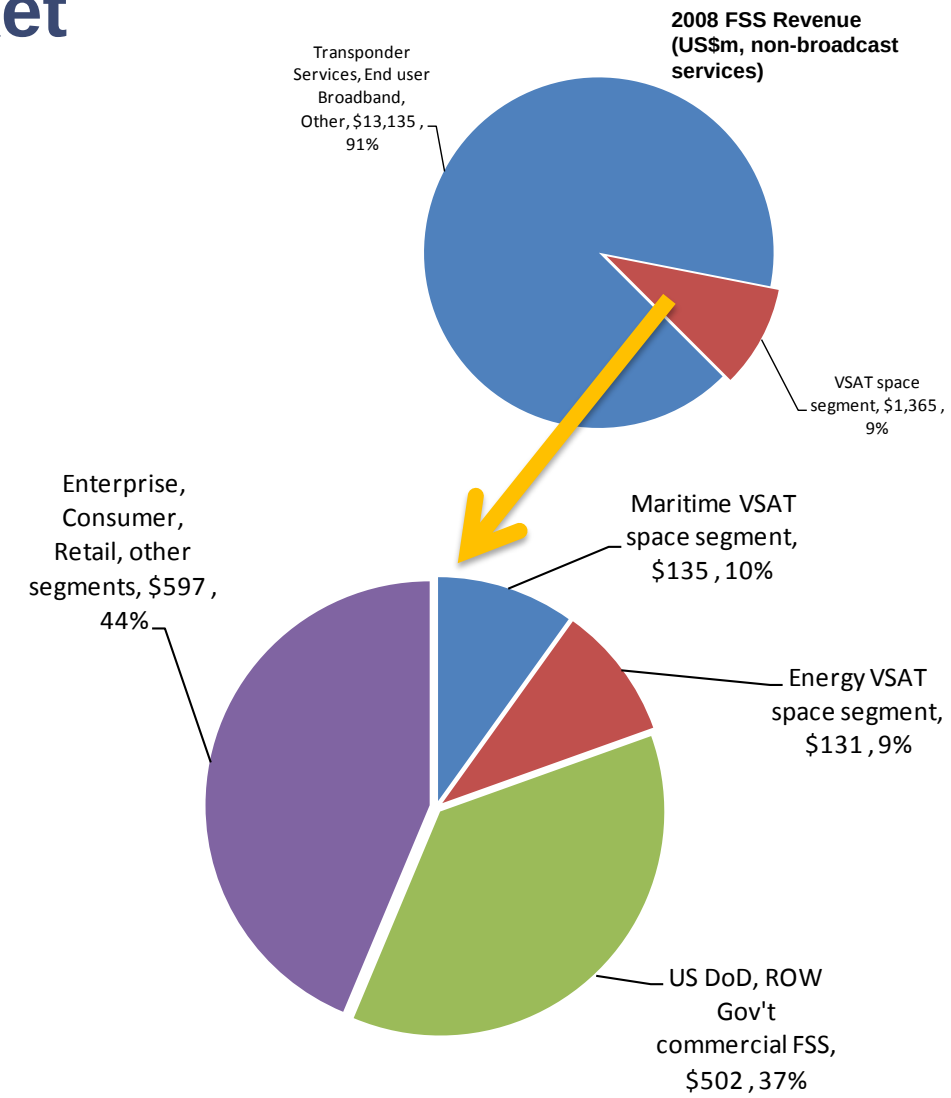
# The addressable market for Global Xpress

- Maritime, energy and government are substantial and growing strongly
- These segments reflect Inmarsat's current and historical business focus and core competencies
- Combined target markets ~US$ 800m and growing
- Enterprise & commercial aero represent 'wild-card' additions




2008 MEG Space Segment Purchases
USD 1.4 billion, 2008

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# The challenges at Ka band

- Rain and other propagation impairments are factors impacting the performance of wireless communications systems.
- Those factors are frequency dependent, and are also affected by specific local parameters, including:
  - Rain rate and rain height
  - Altitude
  - Atmospheric gases
- In the specific case of satellite communications systems, another significant issue is the elevation angle to the satellite.
- Propagation issues have been extensively studied over the last 20 years by the International Telecommunications Union (ITU), European Space Agency, NASA and other agencies.
- Detailed methods have been developed by the ITU to evaluate propagation effects, and have been proved in real systems.

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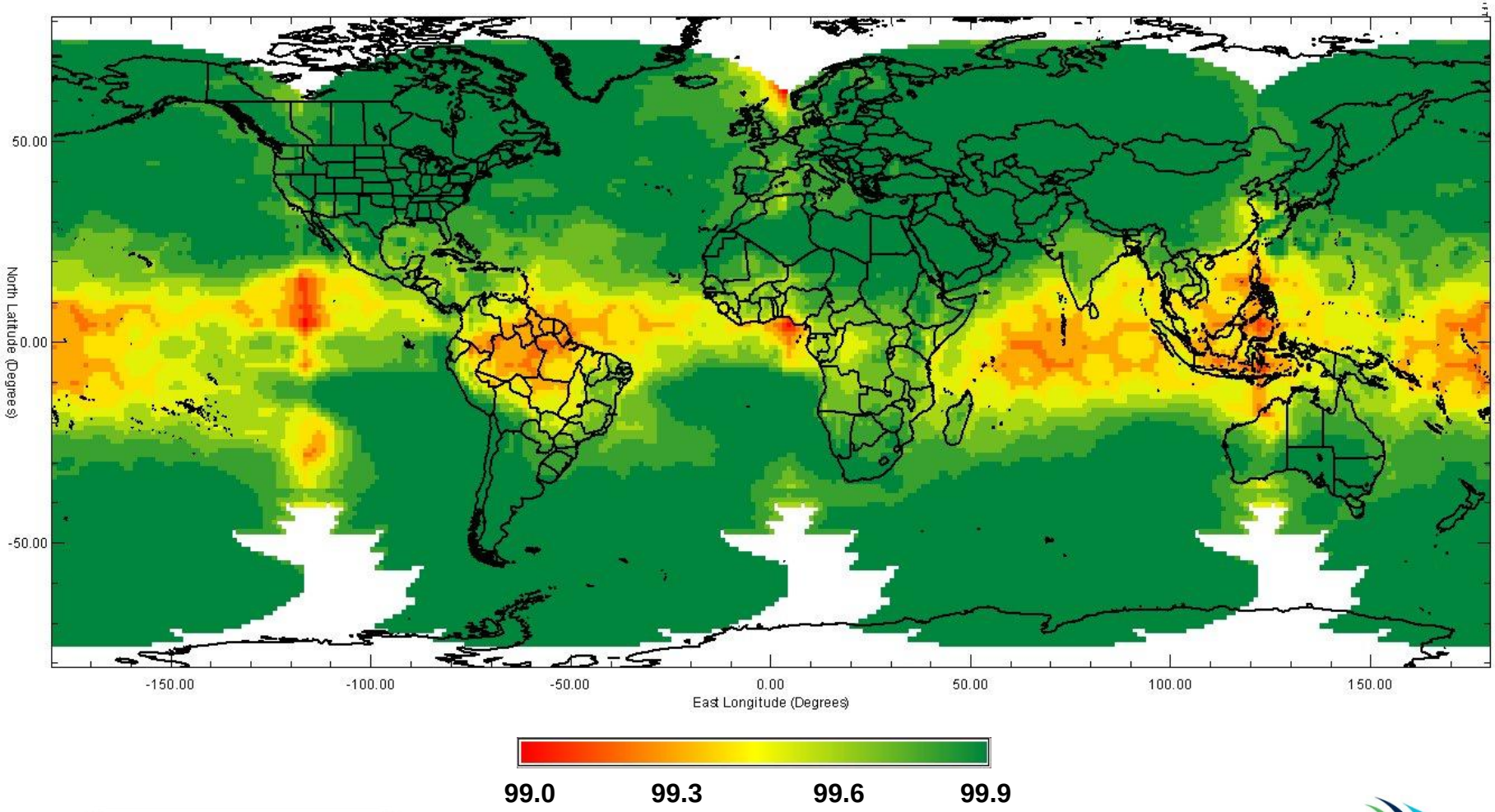
# Solving the problem

- Rain attenuation is the main factor affecting system availability for Ka band satellite systems.
  - *Not an issue for aeronautical applications*
- The main tools to cope with rain attenuation are:
  - adaptive code modulation (ACM)
  - link margin yielded by the user antenna size and satellite power
  - forward link automatic level control (ALC) at the satellite.
- For GX, the combination of those parameters deliver an average user link clear sky margin of 15 dB, for a 60 cm antenna.
- For a 1 m antenna, the average user link margin increases to close to 20 dB.
- The feeder link downlink clear sky margin is around 20 dB on the downlink, increasing to close to 25 dB on the uplink, due to the use of ALC on the satellite.

# Uplink availability (%) for a 60 cm dish

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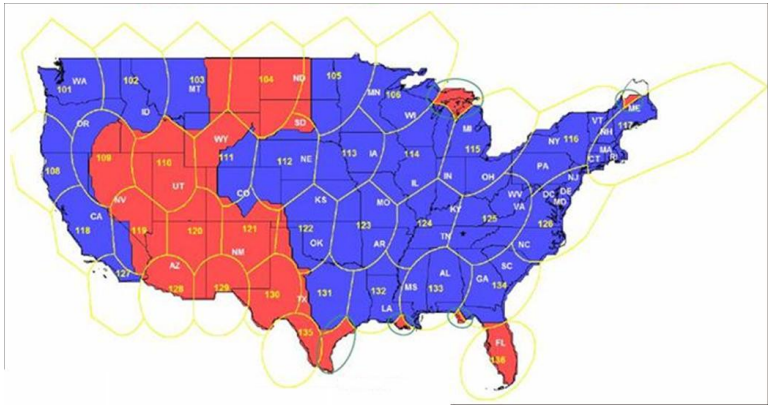
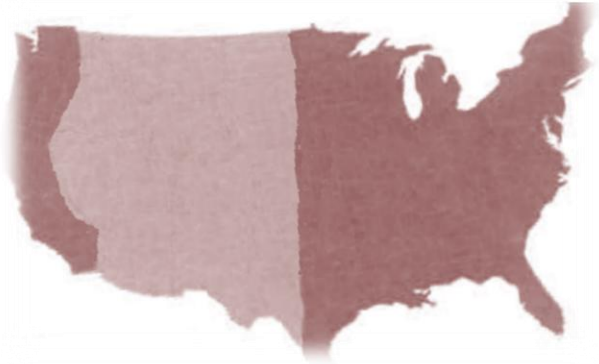
# Next generation satellite systems for consumer broadband

- 1st generation: Wildblue and Spaceway 3
  - Full US coverage
  - Satellite capacity close to 10 Gbps
  - >500k users/satellite
  - Onboard processing (Spaceway 3)
  - Up to ~2 Mbps download
  - ~$150 connection and ~$60/month



- 2nd generation
  - Partial US coverage
    - West Coast & Eastern half of CONUS
  - Satellite capacity close to 100 Gbps
  - ~2M users/satellites
  - Promise improvements in throughput and fees
  - Direct competition with terrestrial networks



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# Divergent paths for innovation

- Coverage versus throughput
  - Global coverage, lower throughput = Inmarsat-5
  - Regional coverage, higher throughput = Viasat-1, Jupiter
- Fixed versus mobile
  - Fixed = Viasat-1, Jupiter
  - Mobile = Inmarsat-5, Spaceway 3
- Scattered communities versus consumer
  - Scattered communities = Inmarsat-5, Spaceway 3
  - Consumer = Viasat-1, Jupiter
- Payload flexibility versus capacity
  - Bent pipe = Inmarsat-5, Viasat-1, Jupiter
  - Onboard processing = Spaceway 3
  - Steerable beams = Inmarsat-5, Spaceway 3
  - Rechannelisation = Spaceway 3, Inmarsat-5

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# Conclusion

- Communications satellites have been an key part of global communications systems for the last 40 years, transforming and adapting to new technologies and user demands.
- The last few years have seen unprecedented growth in demand for data and broadband applications.
- Recent technology developments have made possible a revolution in the provision of broadband services by satellite.
- Avanti is leading the developments for fixed satellite services in Europe with the Hylas 1 & 2 spacecraft
- Inmarsat is leading the world on mobile satellite broadband with the GlobalXpress system, which will offer dramatic improvements in capacity, throughput, user terminal costs and airtime fees.

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