Never Beyond Reach

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Inmarsat’s Global Satellite Services

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Satellite services - 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 1989.
- 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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Inmarsat - a parallel path

- 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
  - Fleet (maritime), Mini-M & 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), SB (aero) and ISatPhone
    - Voice, fax and data at ~0.5 Mbps
- Inmarsat 5 – to be launched in 2013-14
  - Inmarsat GlobalXpress broadband satellite mobility
    - Data at up to 50 Mbps

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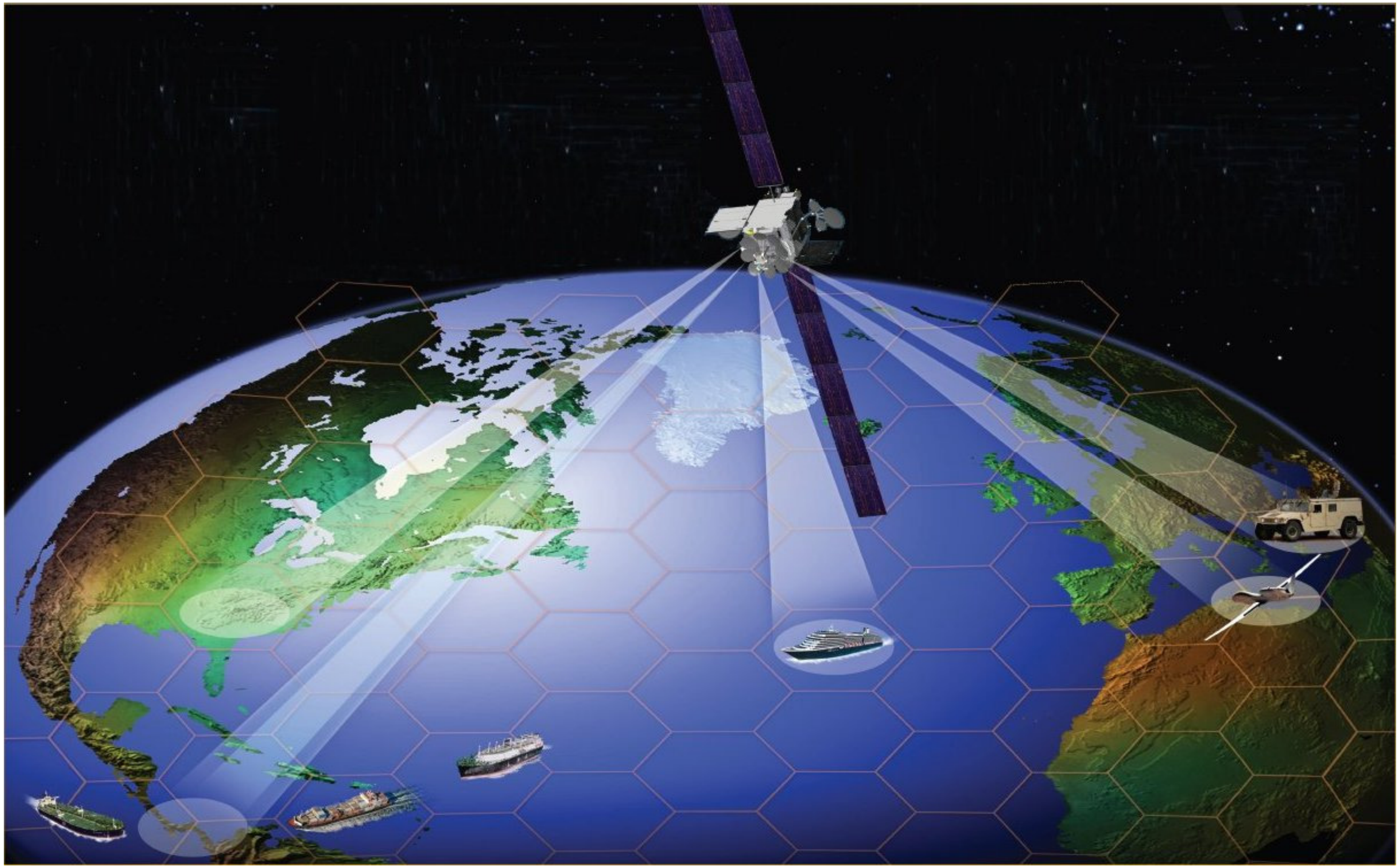
GlobalXpress – global mobile broadband



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Different users, different needs

- 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

Inmarsat 5 Outline

- A new generation of global Ka band broadband MSS
  - Major leaps forward in capacity and throughput
    - >30 x Inmarsat-4 capacity & >50Mbps 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 frequencies

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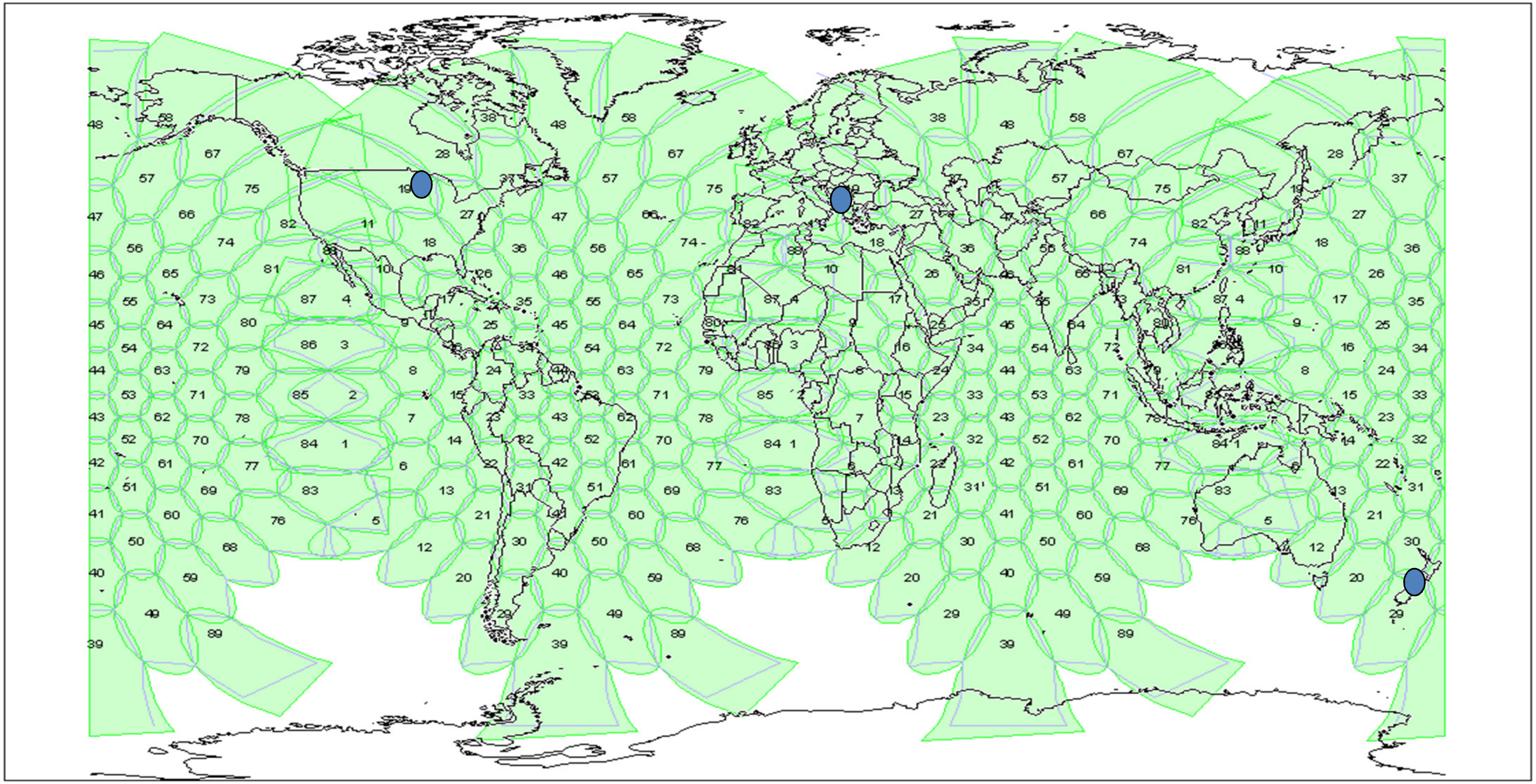
Global coverage



Indicative gateway locations

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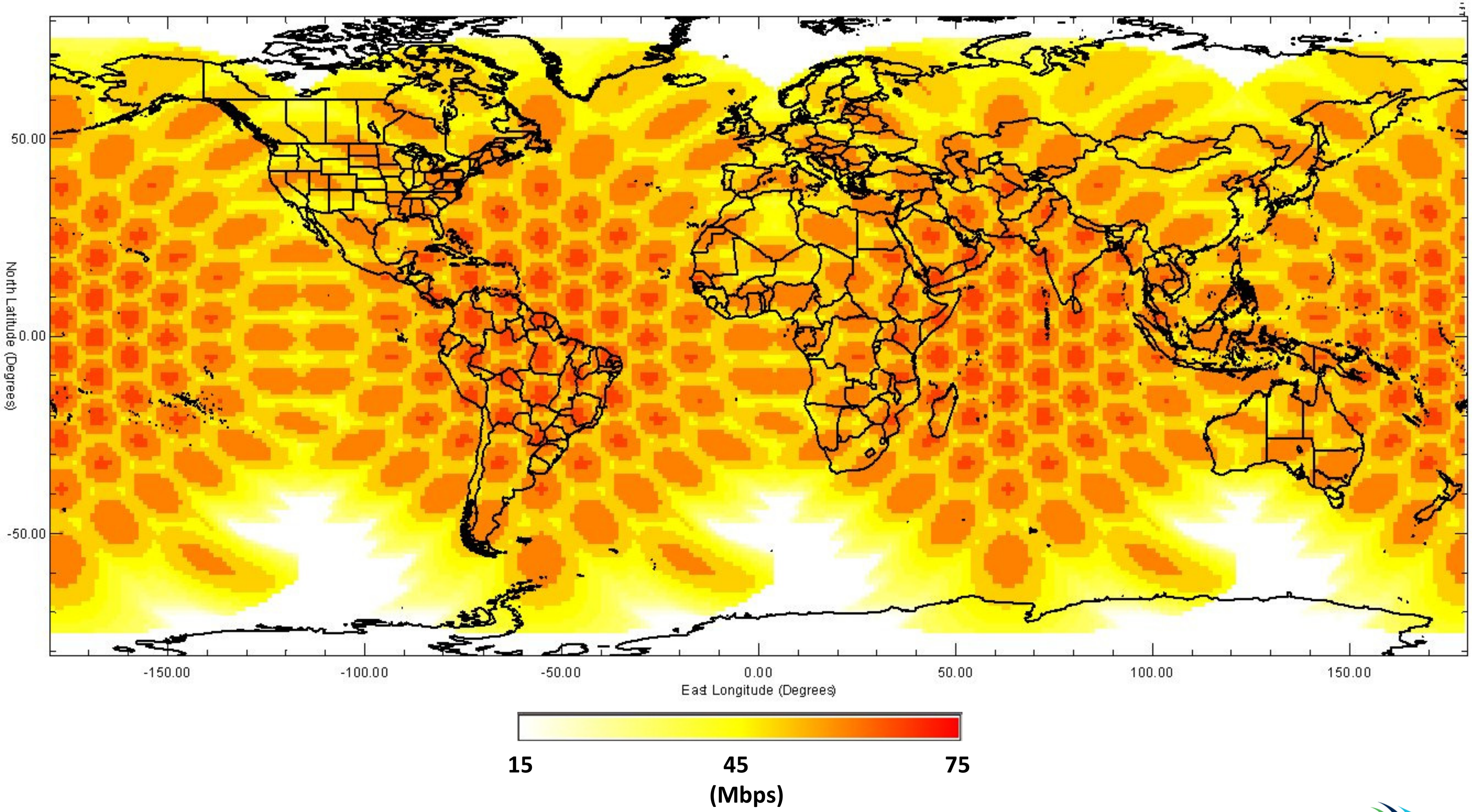
60 cm dish – forward link, clear sky



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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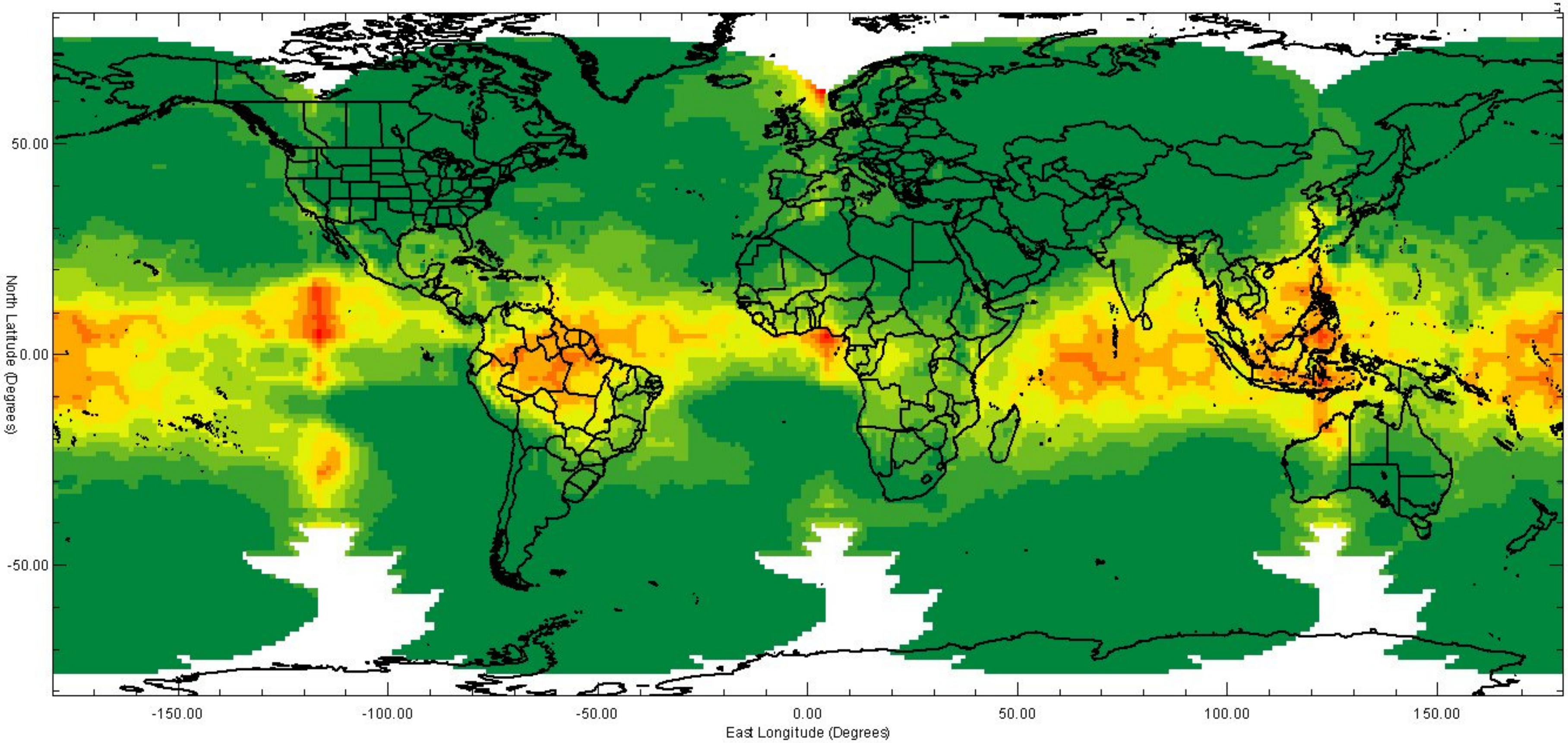
Solving the problem

- 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.

Return link availability for a 60 cm dish



99.0 99.3 99.6 99.9

(% of the time for an average year)

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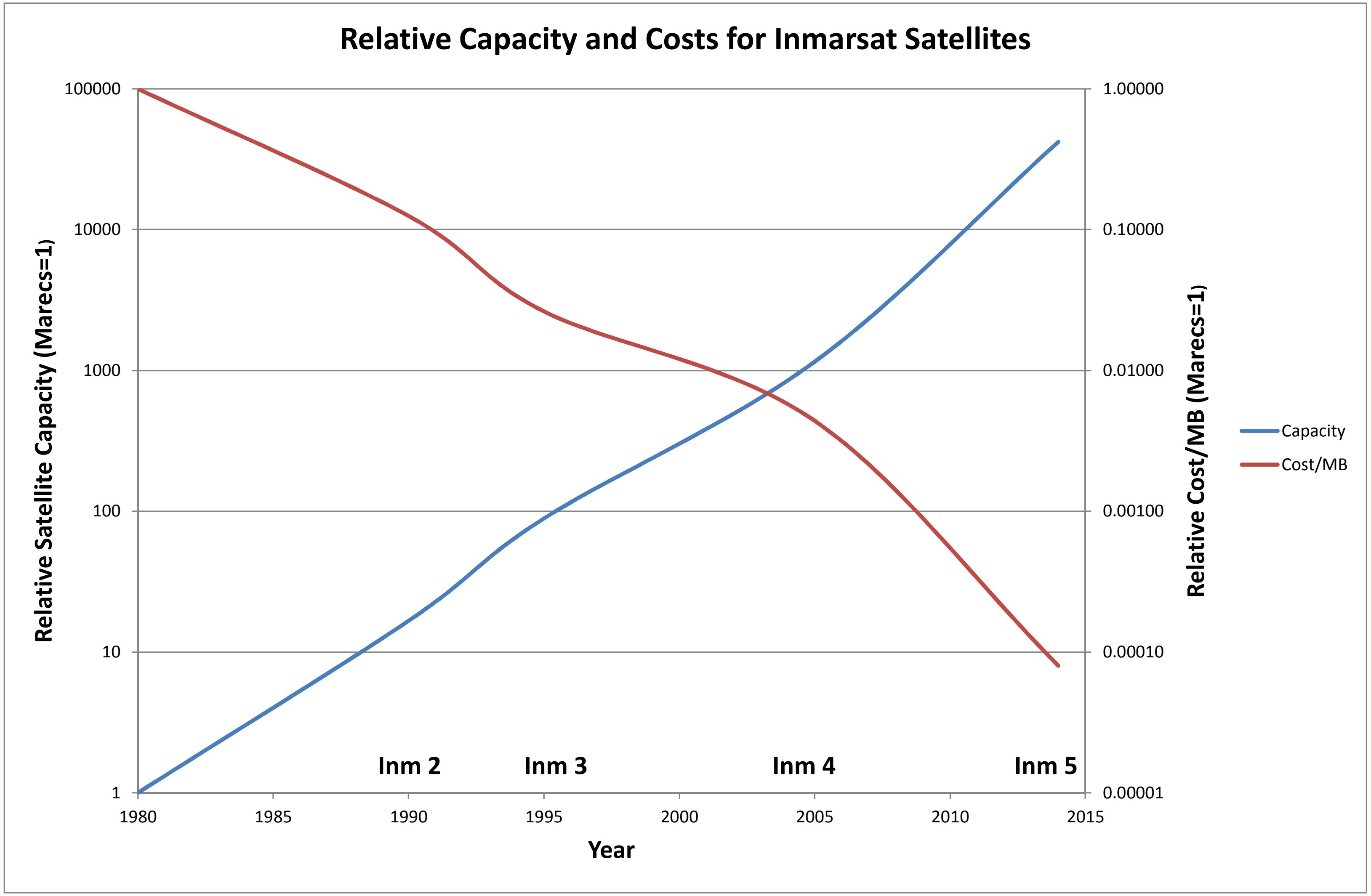
Inmarsat system capacity and cost/MB



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Looking forward

- How to ensure the technologies required to maintain the trends in capacity increase and in cost reduction observed during the last >30 years, are available to us for future systems?
- Satellite
  - Antennas
  - Digital channelisers and beamformers
  - High power SSPA at higher frequency bands
- System
  - Network architecture
  - Higher frequency bands
  - Compression, processing, modulation and coding techniques
- User terminal
  - Battery technology
  - Electronically steered antennas

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.
- We have to continue developing new technologies and exploring ways to ensure that future systems continue to offer higher capabilities and meet user demands.
  - Flat electronically steerable antennas
  - Efficient battery technology
  - Advanced modulation, coding and compression techniques
  - High power/high efficiency solid state power amplifiers
  - More ideas?

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Thank you!