Inflight Connectivity Presentation

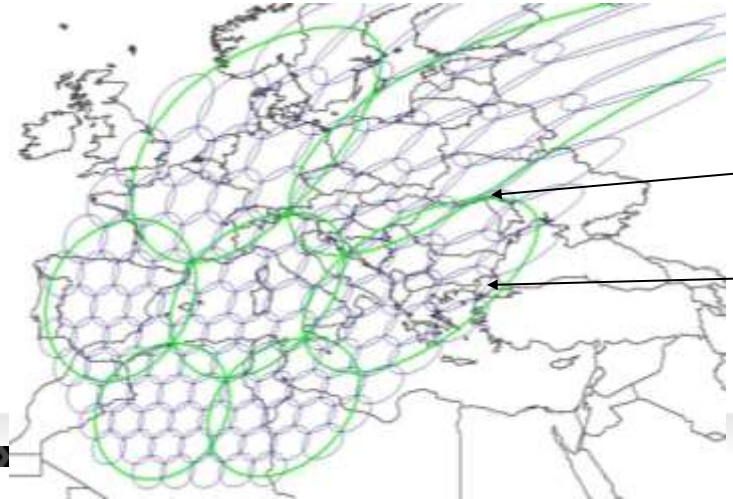
Konference Radiokomunikace

Pardubice 18.10.2017

High Capacity Ka Satellites

- Revolution in throughput
  - ViaSat-1, at 140 Gbps represents more throughput than all other Ku, and Ka US satellites combined
- Spot beams
  - Allows for frequency reuse
    - More effective user bandwidth
  - Improved terminal performance
    - Higher EIRP and G/T

Ku Regional Beam



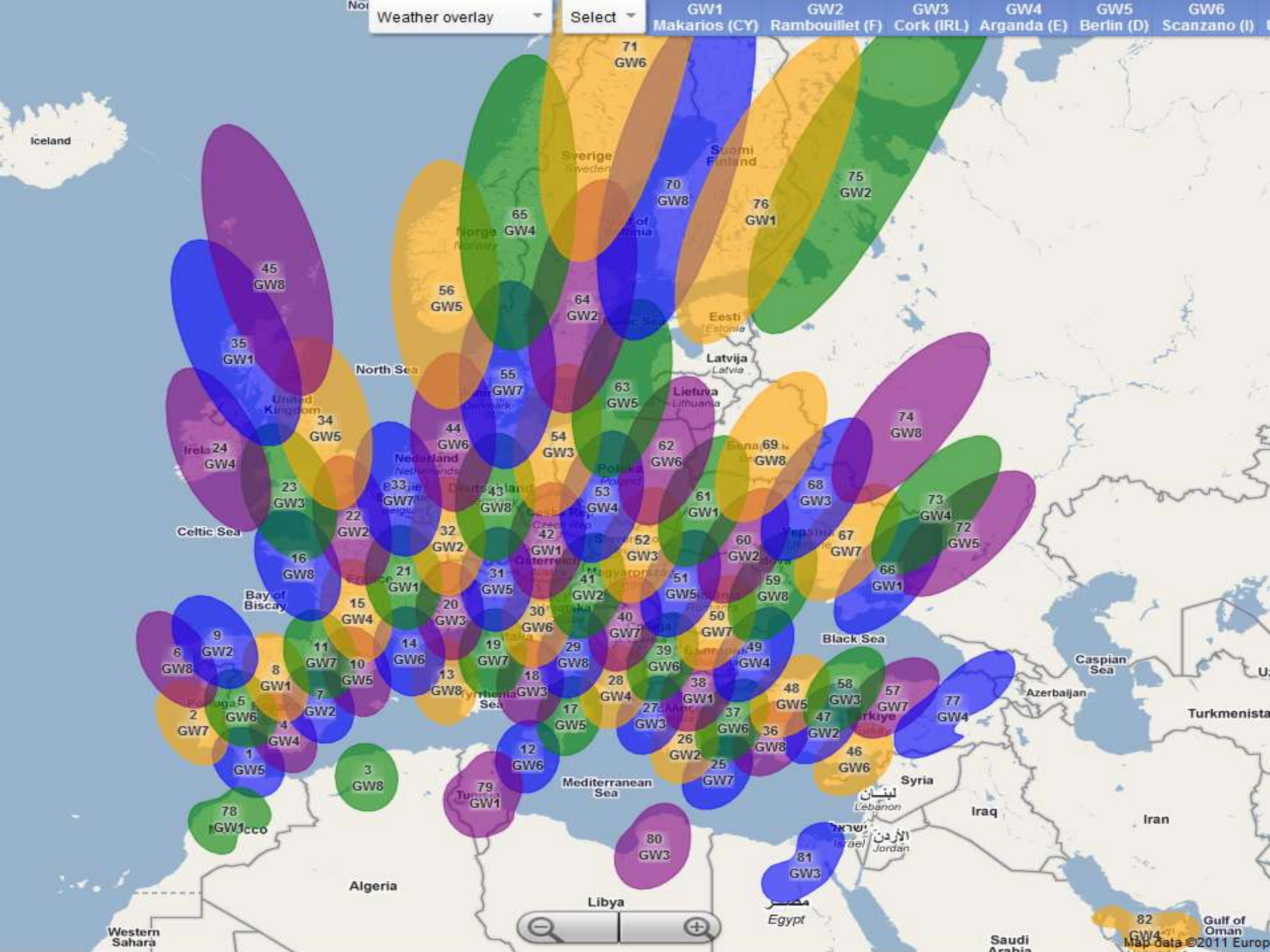
Modern Satellite

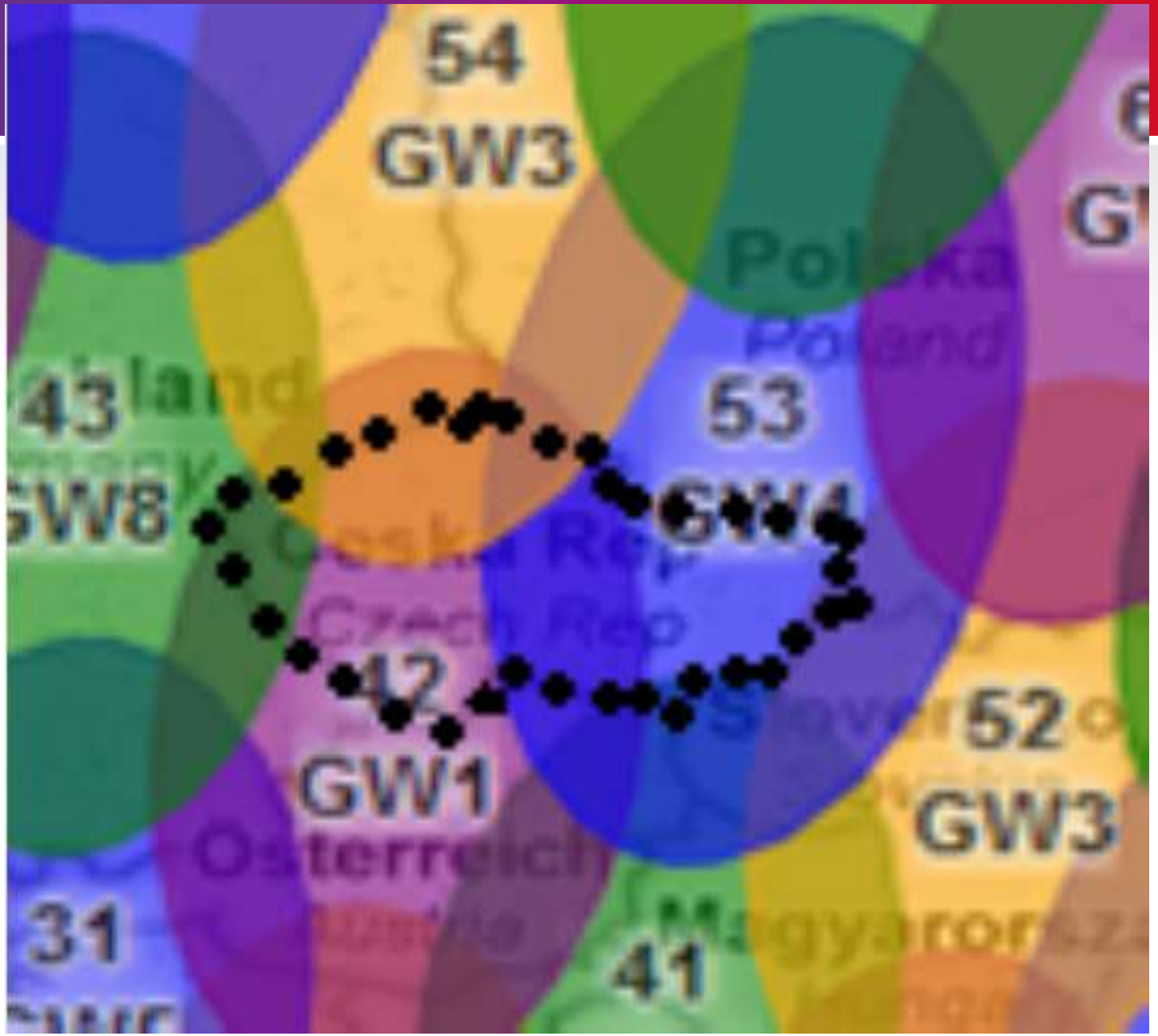
HCS SpotSpot

Effective Bandwidth	
Regional	2 GHz
Modern	7 GHz
HCS	100 GHz

Assumes 1 GHz Spectrum

1 Regional ≈ 7 modern ≈ 100 HCS beams

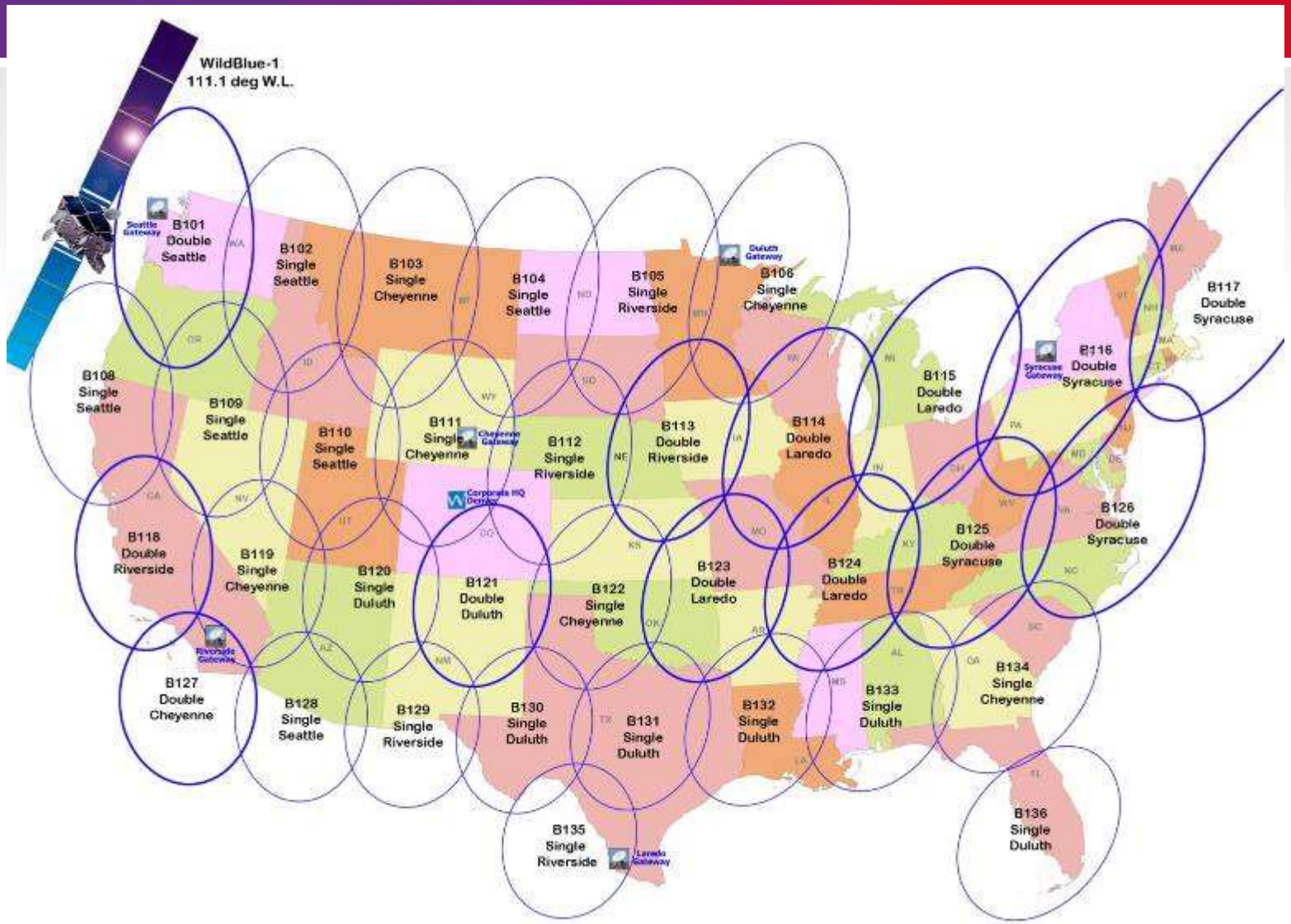

Weather overlay
Select
GW1 Makarios (CY)
GW2 Rambouillet (F)
GW3 Cork (IRL)
GW4 Arganda (E)
GW5 Berlin (D)
GW6 Scanzano (I)
Iceland
Sverige
Suomi Finland
Norge
Eesti
Latvija
Lietuva
North Sea
United Kingdom
Irela
Nederland
Celtic Sea
Bay of Biscay
Black Sea
Caspian Sea
Azerbaijan
Turkmenista
Mediterranean Sea
Syria
Iraq
Iran
Algeria
Libya
Egypt
Western Sahara
Saudi Arabia
Gulf of Oman
Map data ©2011 Europ



Growing Coverage of High Capacity Ka Satellites

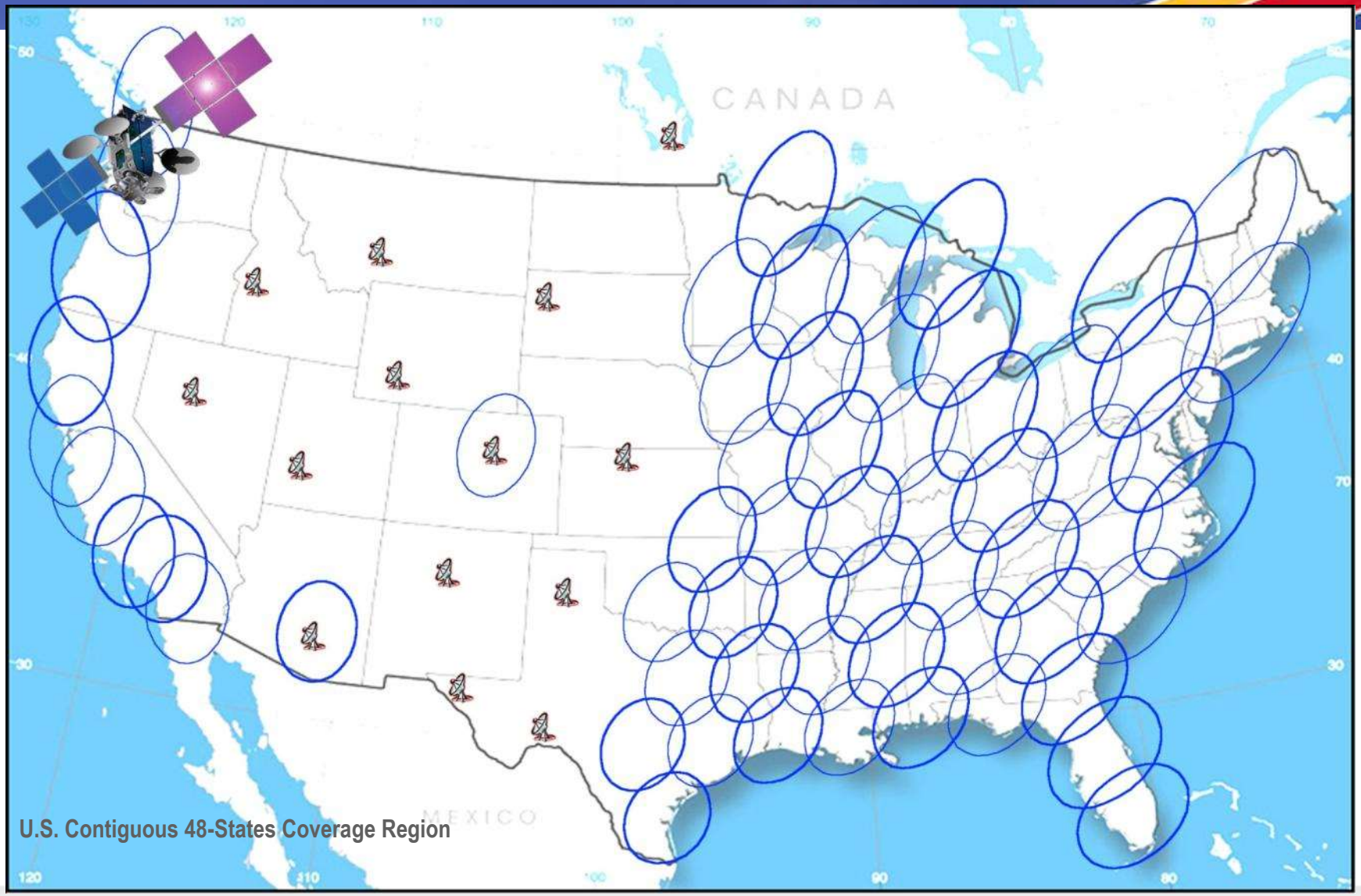
- $1B+ of Ka band satellites
- ~$350M of teleport infrastructure

WildBlue-1 Coverage over U.S.



ViaSat-1 Network Geography

WildBlue.
A ViaSat Company

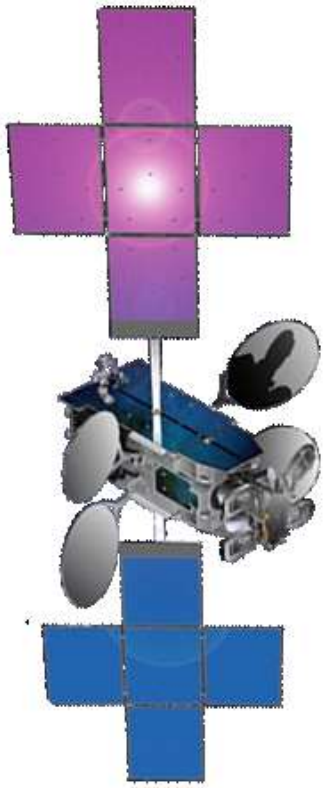


U.S. Contiguous 48-States Coverage Region

Canadia, Alaska, Hawaii Coverage not Shown

ViaSat-1 vs. WildBlue-1

	WildBlue -1 Satellite		ViaSat-1 Satellite
Satellite Frequency Plan	35 beams	2 ×	70 beams
Average	170 MHz/beam	9 ×	1500 MHz/beam
Total Satellite Bandwidth	6 GHz Up + Down	18 ×	105 GHz Up + Down
Estimated Satellite Capacity	8-10 Gbps	10-12 ×	120-130 Gbps

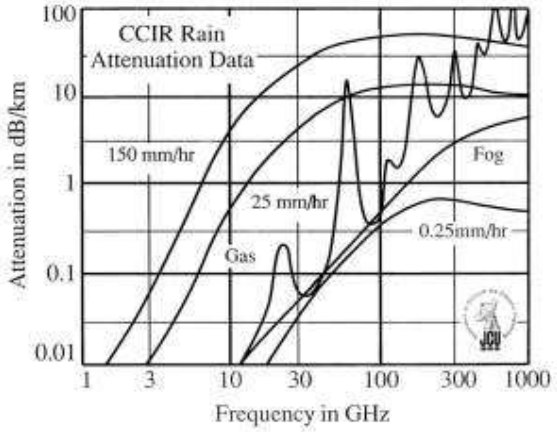


High Capacity Ka-Band Satellites

Facts to be considered

»Ka-Band Advantages

- More available spectrum
- High power spot beams
- Frequency re-use
- High EIRP and G/T
- Smaller terminals
- Innovative technology to mitigate propagation impacts



»Ka-Band Mitigation

- Adv.Uplink Power Control
  - High dynamic range
  - Short update interval
  - Fast fade adaption
- ACM
  - Converts Link Margin to Data Rate Margin
  - Hitless adaptation of Coding & Modulation
  - Constant symbol rate and power level
- WAN Acceleration

Ka-Band Advantages Prevail

ViaSat

Speed vs Capacity

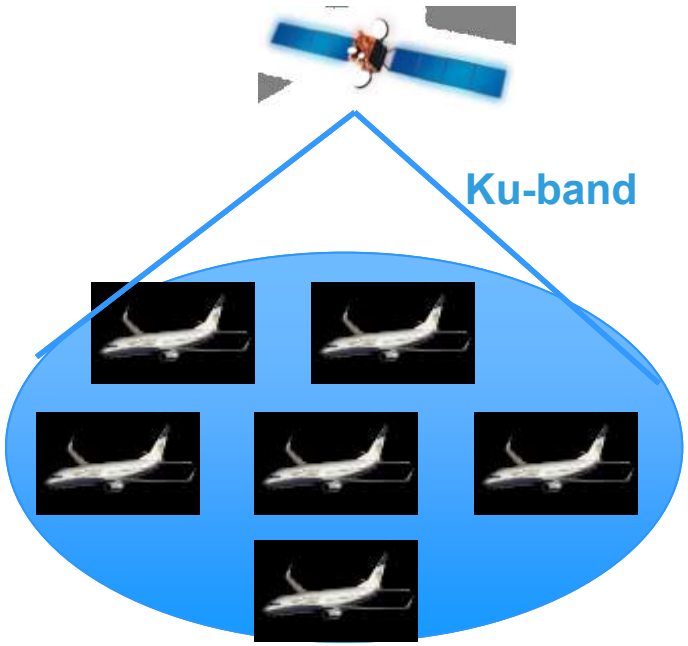
- Peak Speed to Aircraft on ViaSat
  - 100+ Mbps (At Entry Into)
  - 200+ Mbps (Future Growth of System)
- **By itself, however, a speed to the individual plane SLA is not adequate:** It is important to understand the context of a speed claim
  - Peak or average speed to an individual plane?
  - Peak or average speed to individual passengers?
  - Speed experienced by passenger when the system is congested?

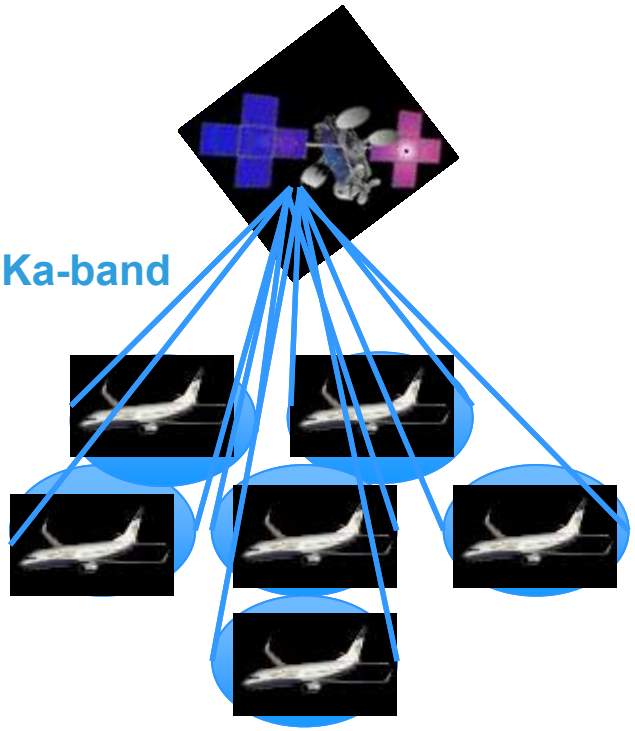
The only thing that matters is the speed that an individual passenger actually experiences and that is a function of all of the above combined, most importantly, with the total available capacity, and the capacity density of the system!

Capacity Density is the key to passenger internet experience!

Why ViaSat HC Ka-band Provides the Highest Quality Service

- Smaller beams + More Spectrum = Better service
- Satellite bandwidth must be shared among users – the more users in any given beam, the less bandwidth per user
- With small spot beams, less aircraft are competing for the transponder resources

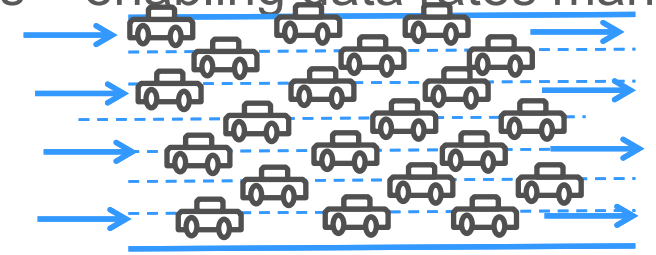




Bigger pipe = faster speeds

- Due to regulatory restrictions, only 250 MHz of satellite spectrum is available to satellites in the Ku-band in any given region
  - Ku-band transponders usually broken into 36 MHz transponders, meaning capacity is added in 36 MHz increments
- At Ka-band, up to 1,000 MHz of satellite spectrum is available for use.
  - ViaSat class High Capacity Ka-band satellite transponders use 250-10000 MHz transponders – enabling data rates many times faster than Ku-band.

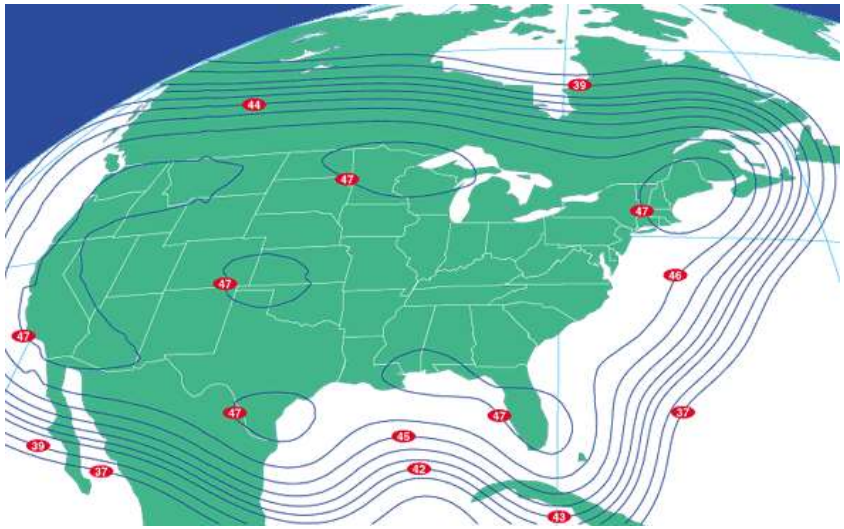
Ku-band or Thin-Ka (GX)



ViaSat class High Capacity Ka-band

Typical Ku-band satellite

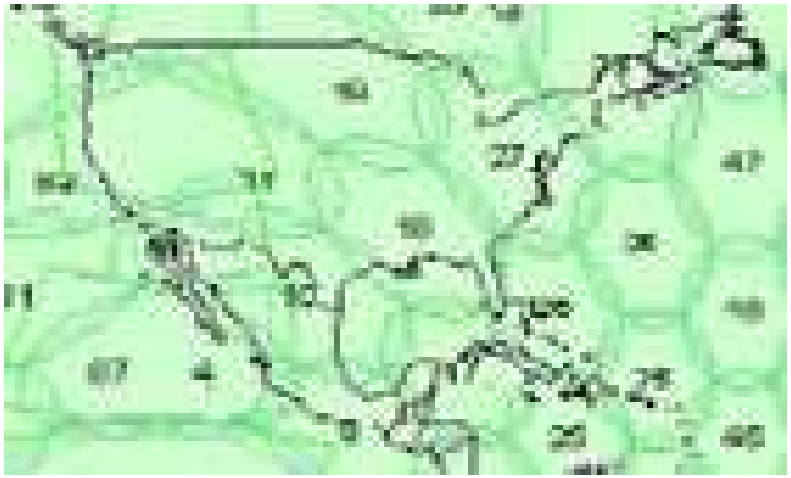
- Ku-band transponders typically have continental coverage (e.g. North America or Europe)
- Typical 36 MHz transponder can typically support up to 30-40 Mbps of capacity



- All aircraft in the coverage area have to share that capacity – more aircraft means slower speed/aircraft

What about GX?

- While GX spot beams are smaller than Ku-band, they are still relatively large (2000 km x 1800 km over N America)

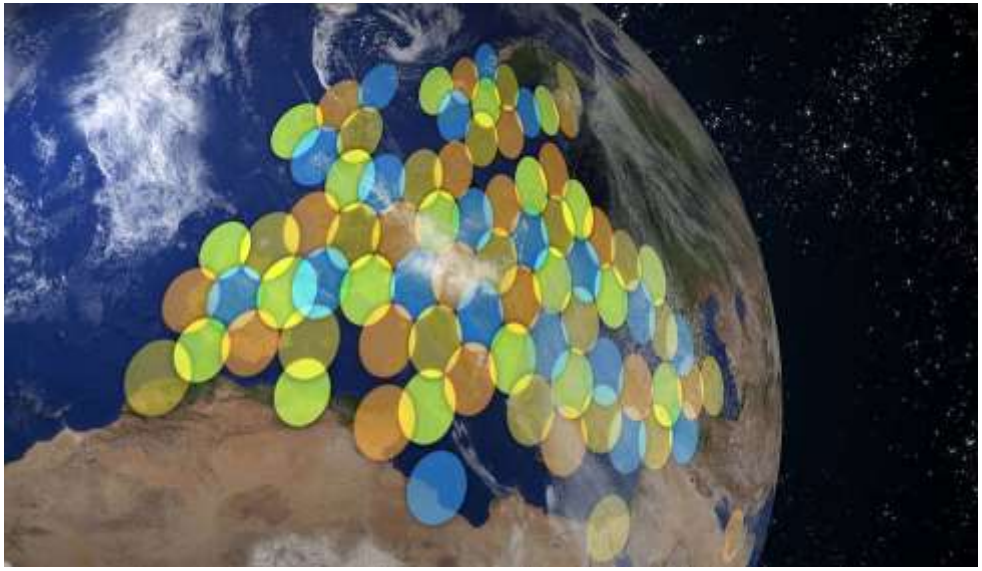


- Frequency reuse pattern means that each beam has access to only 32 MHz (Max of 40-50 Mbps/beam)
- All aircraft in the coverage area have to share that capacity – more aircraft means slower speed/aircraft

ViaSat High Capacity Ka-band satellites

- ViaSat-1 class High Capacity Ka-band satellites use very small spot beams - roughly 900 kms wide

- More intensive frequency reuse pattern means that each beam has access 250 - 1000 MHz (Up to 1+ Gbps beam)
- Smaller spot beams mean fewer aircraft are sharing more bandwidth in a given location (esp. in high-density areas)
- New satellites will have high-capacity beams over cities/areas with heaviest traffic



Spectrum Density

	Ku-band	GX	KaSat
Transponder size	36-54 MHz	32 MHz	**250 MHz**
Geographic area covered by transponder (in kms$^{2)}$	11,309,734	2,764,601	**502,654**
Spectrum density (Hz/km^2)	3.2 - 4.8	11.6	**497.3**

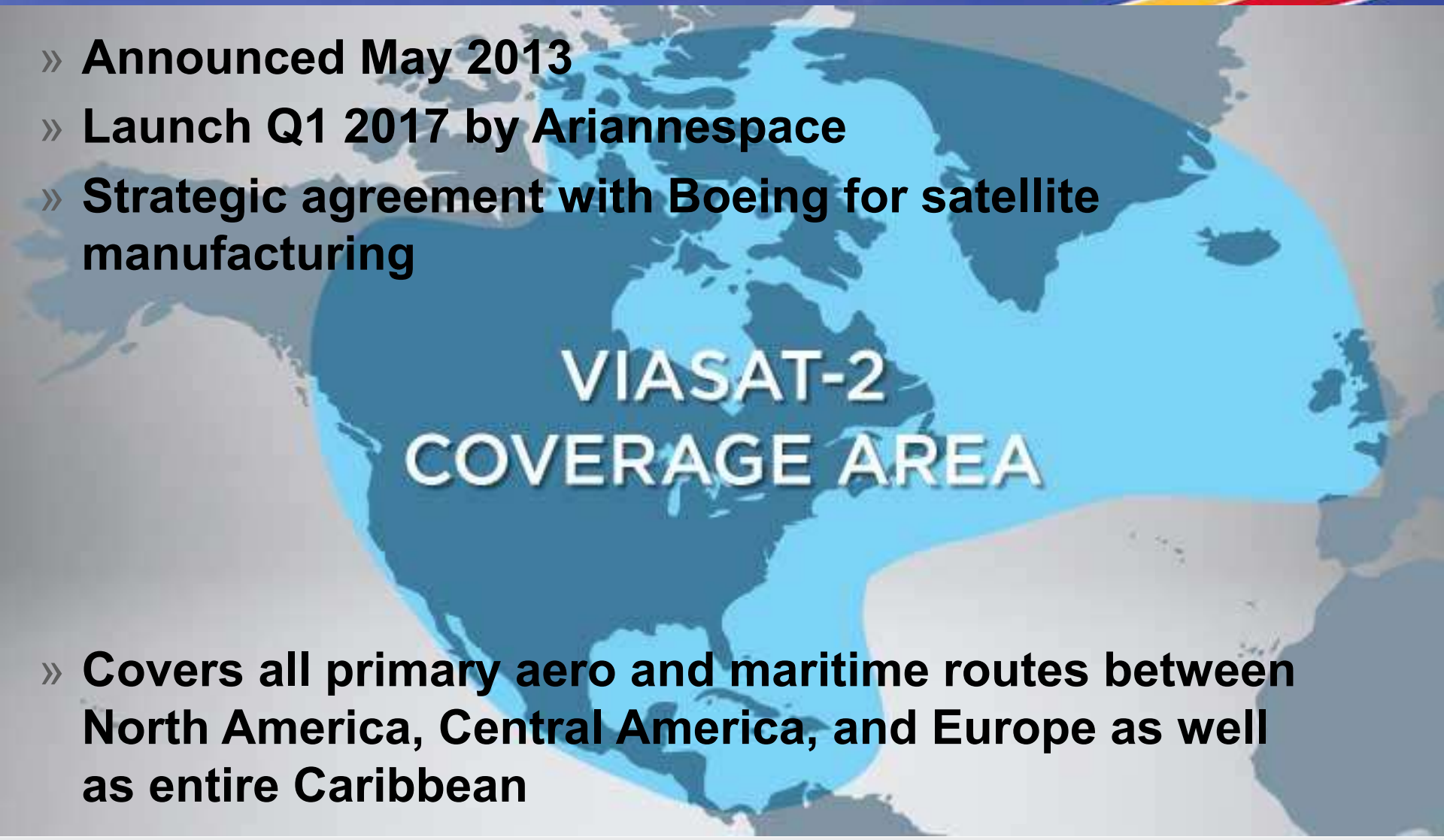
- ViaSat High Capacity Ka-band satellites have more spectrum available over a smaller geographic area than Ku-band or GX
- Smaller number of users share a larger amount of bandwidth enabling higher bandwidth to more users

How Much Bandwidth is Required to Serve All Aircraft in 300 nm Airspace?

	ViaSat VS-1	Inmarsat GX	Intelsat EPIC	Wideband Ku	Gogo ATG
Beam size	100 nm	500 nm	300 nm		80 nm
Data rate per beam	~1Gbps	~50Mbps	200Mbps	~20 Mbps	3-10 Mbps
Beams in region	10	1	1	1	15
Total capacity in region	~10 Gbps	~50Mbps	200Mbps	~20 Mbps	~100 Mps

ViaSat-2: Continuing the Revolution

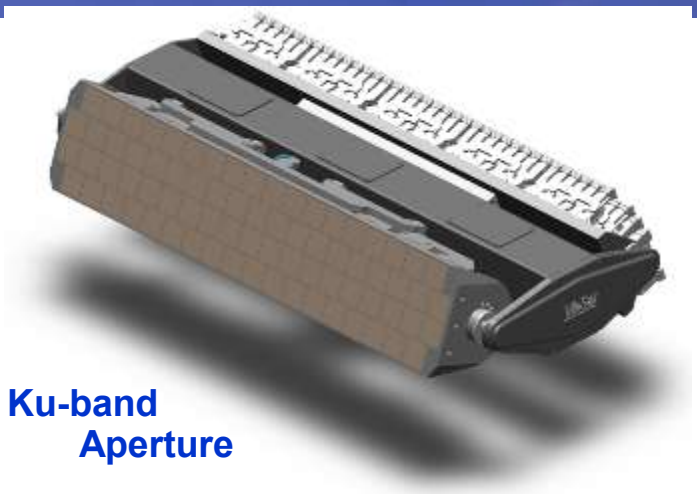
- **Announced May 2013**
- **Launch Q1 2017 by Ariannespace**
- **Strategic agreement with Boeing for satellite manufacturing**



- **Covers all primary aero and maritime routes between North America, Central America, and Europe as well as entire Caribbean**

ViaSat-3 Global Tbps Coverage

KuKarray Antenna



Ku-band Aperture

Ka-band Aperture

- KuKarray combines Ku-band and Ka-band into a single antenna
- Uses the Mantarray positioner, ACU, aperture and RF electronics
- Switching from Ka-band to Ku-band requires the antenna to simply rotate approximately 180° in azimuth to point at the alternate satellite location

Medium Profile Radome

KuKarray Mounted Under a Radome

- **The radome provides protection to the antenna while reducing aerodynamic drag**
  - Radome shell is common to various aircraft types
  - Antenna and radome mounting fixtures will vary depending on aircraft type
- **The dielectric construction allows RF signals to pass through at both Ku &**

Growing Customer Base, 500+ aircraft in service today

jetBlue AIRWAYS

SAS

United Airlines

American Airlines

Virgin america

QANTAS

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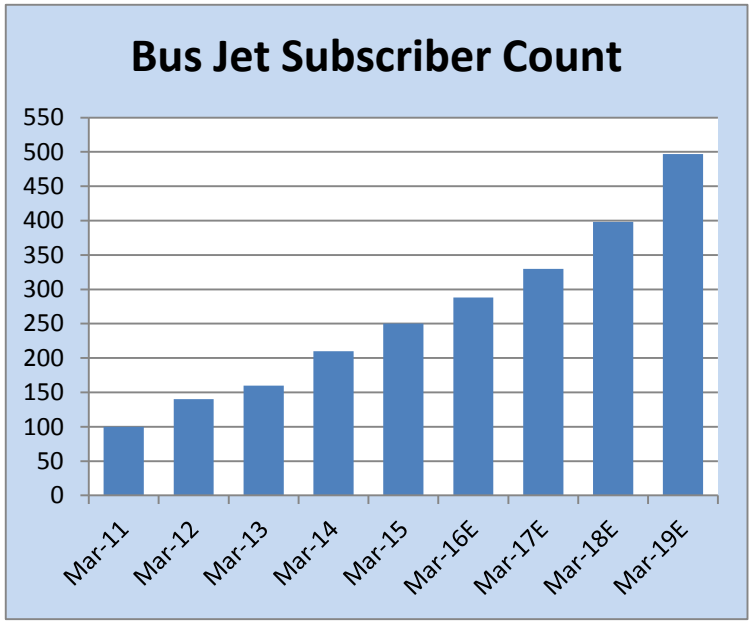
Business Aviation at ViaSat – C w



ViaSat Ka BizAv Market Segmentation

Gulfstream G-IV,V,450/550/650/500/600

Dassault Falcon 7X/5X/8X

Bombardier Global 5000/6K/7K/8K

Market Segment	Dassault	Gulfstream Large Cabin	Bombardier	Bombardier through NetJets	Bombardier through Completion Centers	Medium & Small Cabin*
Long Range, Long Flight times	✓	✓	✓	✓	✓	
Transocean	✓	✓	✓	✓	✓	
Under ViaSat Footprint	✓	✓		✓		✓
Cabin Amenities (Office in the Sky)	✓	✓		✓	✓	
Can Afford BB Internet	✓	✓	✓	✓	✓	
Fly in Busy Corridors	✓	✓	✓	✓	✓	✓
	* Lear, Cessena, Hawker, G250's, G280's, etc. are VMS Candidates					

3,800 Business Jets - Potential Addressable Market Using Conventional Tailmount Antennas

- Includes Following Manufacturers' Jets:
  - Bombardier Global's and Challengers 350, 604, 605
  - Cessna Citation X
  - Dassault Falcons 900, 2000, 7X
  - Embraer Legacy 500
  - Gulfstream G-IV, G-V, G450, G550, G650
- This number grows to 16,500 with additional antenna
  - Fuselage mount Phased Array very attractive to small and mid cabin Business Jets
  - Added addressable platforms include Cessa Citation, Bombardier Challenger, Embraer Phenom and Legacy, Gulfstream G150/G280, Learjet 70/75/45, and Pilatus PC-24


SPACE SYSTEMS
LORAL
Volga-Dnepr
Волга Днепр