Earth Stations In Motion
Evolutionary not Revolutionary
ESIM Networks Evolving

› Transition from symmetric reflector to more complex antennas to solve low profile / drag requirements
  › Radiation patterns different than classic reflector antennas
  › Mitigated through network management controls and regulatory processes like coordination
  › See ETSI Technical Report 103 233

› Desire for constant connectivity drives mobility solutions that roam between satellites – strong demand for in-flight WiFi
  › Antennas need to switch between satellites quickly and IP networking designs needs to keep links active while dealing with IP packets that suddenly switch between satellite gateways

› HTS satellite evolution using large numbers of spot beams requires seamless switching between both spots and satellites
  › Adds additional IP networking complexity
  › Frequency reuse patterns may require changing between bands and/or polarization
ESIM Deployment Leads Regulatory

Industry leading, Regulatory lagging
- Local and Regional regulatory frameworks developing well
- ITU regulatory status progressing much more slowly
- ITU status for ESIMs in 29.5-30 GHz band OK, but 27.5-29.5 GHz band still in progress – could result in Swiss Cheese holes in coverage on some satellites

Earth stations in motion designed to appear to FSS spacecraft as just another FSS earth station.
- Network controls in place to assure harmonious operation with existing FS and FSS networks
- If a fixed earth station can operate there, an ESIM will look the same to other services nearby
- Not many aeronautical fixed earth stations. Aero ESIM sharing studies and airframe blockage data will be key drivers
Notional Flight Route Densities
ViaSat High Capacity Ka-band Coverage
Global Route Coverage

» Hybrid Ku/Ka System
» Best Available Network
  › Highest Capacity
  › Fastest Speeds
  › Global Coverage
» Best Value to the Airline
  › Lowest Cost Per MB
» Future Proof
  › Decreasing MB Cost and Increased Capacity allows airlines to keep up with on-the-ground demand!
We’ve Already Flown It!

Successful Ku and Ka operations and transitions between (6) satellites utilizing (3) networks
Current Ka Band Network Coverage – U.S.
Reliable Routine Operation

From Tuesday Morning, 30 September
Fleet view

- Normal flights
- Below 10,000 Ft.
- Moving Out of Coverage
Mobile terminal details

Tail ID: N950JT
Number of PEDs: 164
MAC Address: 00:AO:BC:6A:43:4D
Beam ID: 170
Flight Status: Normal
Origin: New York, NY (JFK)
Destination: Las Vegas, NV (LAS)
Flight ID: 3B4411
Aircraft: 321-200
Departure: 2016/06/02 14:32 UTC
Est. Arrival: 2016/06/02 19:17 UTC
Altitude: 31525.10 ft
Speed: 19.76 mph
Latitude: 36.14
Longitude: -111.16
HF Ping Test: 100%
ACRU Ping Test: 100%
CSP Connected: True
Time: 2016/06/02 18:43 UTC
Passenger Usage is High!

- JetBlue free service allows for full web browsing, email, social networking, VPN & short video clips
  - Long form streaming (Netflix, Hulu) offered as premium service
- Average passenger consumes ~ 70 megabytes
  - 140 MB per passenger typical on longer flights
- Today ViaSat delivers > 12 TB/Month to 75 aircraft

14 GB consumed on this flight
Common Terminal Control Features

» Constant monitoring of antenna pointing performance
  › Transmissions inhibited if mispointing exceeds threshold

» Transmit power or EIRP density managed by the NCMC
  › End users can’t increase output power on their own

» Terminals are location aware
  › Transmit enable and EIRP density are controlled as a function of geographic location restrictions.

» Terminals are designed to inhibit transmissions if a fault that might cause interference occurs

» Most terminals support data logging of location, platform attitude, frequency, power, etc.
Common Network Control Features

» Network security: system entry is controlled through secure access mechanisms with a level of terminal identity protection to avoid the introduction of rogue or unauthorized terminals or unauthorized operational modes of authorized terminals.

» Regulatory off axis emission limit control: The network combined with the terminal carefully control the off axis emission limits:
  › Location based transmission PSD control with adaptive coding and modulation to maintain the most efficient link possible in the earth station location at any given time, while managing maximum EIRP density.

» Location based regulatory control. As the physical location of the ESOMP is known by the ESOMP and within the network, this knowledge allows adaption of operation based upon location. This can range from reduced EIRP density to full cessation of transmissions:
  › Transmissions can be inhibited over / in countries where operation is not yet licensed.
  › EIRP density reduced or inhibited to protect terrestrial systems.
Sample Test Flight Location Logging
Sample Return Link Eb/No from Data Log
Conclusion

» Earth stations in-motion are operating today under network control and been providing valuable service to users world-wide for years without causing interference.

» Ka band ESIM are operating today using FSS spacecraft and as part of current VSAT networks. Accordingly they are designed to operate compatibly, i.e. looking to the network like just another fixed VSAT earth station.

» Ka band ESIMs operating under network control have so far equaled the great interference free track record of Ku band in-motion earth stations

» ITU regulatory status lagging reality
  › Work should be based on valid technical concerns not held up by political or ideological issues