Maritime Satellite Market Overview

January 16th, 2014
NSF

Steve Foley

Scripps Institution of Oceanography

The Maritime Market

- A relatively small market
- Mostly merchant ships, but some large and coastal yachts
- Includes trans-oceanic aircraft, too
- Goals include:
  - Fleet tracking/operations and remote-office solutions
  - Quality of life at sea/air
- Challenges include:
  - Stabilized antennas for any significant bandwidth, often power limited
  - Ships can be anywhere, but are generally in the shipping lanes, but not near large populations
  - Most of the market is still fairly coastal
  - Weather issues (rain and stability)

Satellite Market Changing

- Large new spectrum (Ka) is coming into play in 2013-2015
- New multi-band antennas are coming to market 2013
- Smaller antennas near the physical limit
- Increased focus on providing end-to-end service to end user

Satellite Market Changing

- New modems
  - Hub and hub-less TDMA and SCPC in one unit (increased flexibility)
  - Paired carrier (up to 50% efficiency increase)
  - Sharper rolloff (~15% efficiency increase)
  - More and adaptive FEC and modulation choices (better power efficiency for smaller antennas and amplifiers)
  - Better remote control and network

Bets Have Been Placed

- Intelsat - "EpicNG"
  - Aiming for "commercial" market of C-band and Ku-band users
  - C-band for global comms (at any speed), Ku and Ka when close to shore
  - Dual band, single feed antennas by SeaTel
  - IP service can be offered by IntelsatOne services
  - First 2 satellites up 2014-2015
- Inmarsat
  - Aiming for "consumer" market
  - L-band globally (up to 432kbps), Ka when in a spot beam (coverage dependent on demand)
  - Data plans serviced through Inmarsat
  - Satellite app store-like development platform on Cisco
  - 3+ satellites being launched 2013-2015

Satellite Frequency Bands

- L-band (~1 GHz)
- C-band (~6 GHz)
- Ku-band (~14 GHz)
- Ka-band (~18 GHz)

L-band

- Pros:
  - Sweet spot of satellite communication spectrum
  - Global coverage, small antennas, low power
  - Packaged as a service by Inmarsat
- Cons:
  - Small spectrum
  - Limited capacity (~500kbps now, 1.5Mbit in the future)
  - Not many L-band satellites up there, really only Inmarsat and Iridium (in the future)

C-band

- Pros:
  - Lots of C-band satellites in the sky
  - Global footprint coverage
  - Hemisphere footprints, too
  - Minor rain fade issues (1.6 dB at 20 mm/hr)
  - Capable of high data rates on newer satellites with sufficient amp
- Cons:
  - Requires larger antennas (2.4m minimum)
  - Requires larger amplifier
  - Affected by terrestrial interference (TI) = more rules/ regulation
  - More work to obtain a TX License

Ku-band

- Pros:
  - Can use smaller (~1m) antennas for a focused beam
  - Requires less power per bit than C-band = smaller amplifier
  - Less interference problems (farther from other bands) = less regulation
- Cons:
  - Bigger rain fade issues (1.8 dB at 5mm/hr, 2.9 dB at 10mm/hr)
  - No global footprints, all based on continents due to broadcast market focus

Ka-band

- Pros
  - Large chunk of spectrum, so high capacity is possible
  - Can use small 0.6-1.0m antennas efficiently
- Cons
  - Limited footprint, spot beams a must
  - Potential rain fade issues (several dB at 5-10mm/hr)

Beams

- Global beams
  - Always on, static, ~72N to 72S
- Hemisphere beams
  - Usually half the size of globals, twice the power, over land
  - Always on, static
- Spot beams
  - Small
  - Static or steerable
  - Dynamically assigned capacity from the satellite's resources

Current Technologies

- Iridium
- Inmarsat Fleet BroadBand (FBB) [L-band]
- Inmarsat GlobalXpress (GX) [L/Ka band]
- Intelsat EpicNG [C/Ku/Ka band]
- VSAT SCPC [C/Ku band]
- VSAT TDMA [C/Ku band]

Iridium

- Low Earth Orbit
- Not all satellites talk back to earth directly
- Next-gen launches are 2015-2017, with data rates of 1.5Mbit (L-band) to 8Mbit (Ka-band)
- Pros:
  - Truly global coverage, pole-to-pole
  - Smaller terminals (0.5m, 25lb)
- Cons:
  - Lower data rates (136kbps at best)
  - No video with current satellites
  - Costly

Fleet BroadBand (FBB)

- Pros:
  - Global coverage
  - Small, reliable antenna
  - Pay-by-the-byte/minute plans for added flexibility
  - IP service provided by 3rd party
  - 24/7 Network Operations Center (NOC)
- Cons:
  - L-band limited speed (432kbps max)
  - Not going to do video with speed
  - Service provided by 3rd party (Acceptable Use, limited flexibility)
  - Higher latency (1200-1400ms RTT)
  - Per byte cost?

Inmarsat GlobalXpress

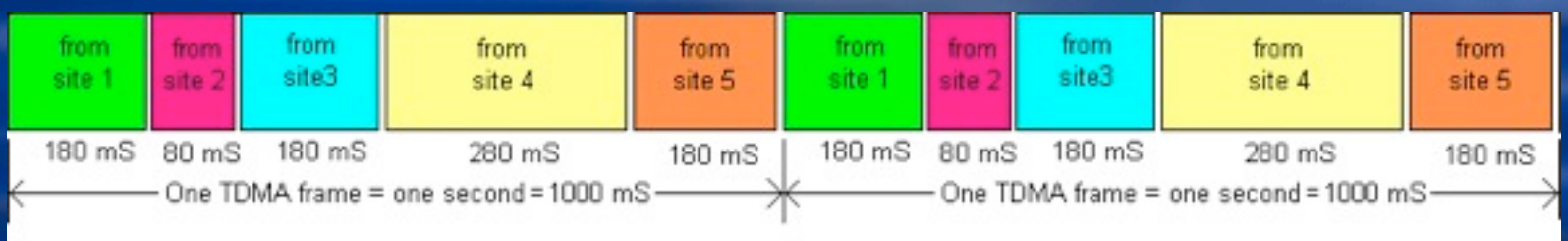
- Pros:
  - Global coverage
  - Small antennas (0.6m or 1m for Ka, and one for FBB)
  - High speed (up to 50Mbit?) Ka-band service when available...may be video-friendly link
  - Support and IP service provided by 3rd party
  - 24/7 Network Operations Center (NOC)
- Cons:
  - Limited speed in L-band coverage (432kbps max)
  - Cannot guarantee high speed bandwidth anywhere or any time (video?)
  - Service provided by 3rd party (limited flexibility)
  - Acceptable Use agreement
  - Ka-band rain fade issues unknown
  - New technology and service, unknown real performance (video?)
  - Not fully global until 2015
  - Cost per real byte?

In-House VSAT SCPC

- This is HiSeasNet in its current form
- Pros:
  - Ultimate flexibility of services offered with bandwidth
  - No bandwidth cost overhead to 3rd party
  - Existing investment in gear, staff, services
  - Do whatever you can with a fixed, static block of bandwidth
- Cons:
  - Limited by earth station size and location
  - Maintenance on equipment
  - Additional bandwidth and location expansion take technical and business work
  - Operations may not be supported 24/7
  - Current equipment is aging and less efficient that new equipment on the market

VSAT TDMA

- VSAT based
- Time Division Multiple Access (TDMA) technology
- Lease a big block of spectrum (many MHz)
- Time slice who gets to talk when
  - More time slices, more resolution
  - Give away extra slices if you have them
  - Can slice in either direction (shore-to-ship or ship-to-shore)
  - Can be fairly dynamic, controlled by hub
- Efficiency hit of ~4%
- Only manages bandwidth in one footprint
- TDMA networks operated by several 3rd party service providers



In-House VSAT TDMA

- Pros:
  - Even better control over ship-to-shore links
  - Can adjust short term (hours/day) to get big amounts of data from one place to another
  - Can be made video friendly
- Cons:
  - Need investment in new gear
  - Need more bandwidth to make this really start to be comfortable

3rd Party VSAT

- Pros:
  - Don't have to operate an earth station
  - Don't have to lease bandwidth directly
  - Can save some cost going TDMA, but less control of network
  - SCPC is an option, too
- Cons:
  - Lose some flexibility as to where the data goes and what services can be handled
  - Subject to acceptable use/service agreement (CIR and best effort usually)
  - Bandwidth may be over subscribed
  - May not be video friendly
  - Pay for services (2x+ the bandwidth cost to get packets onto the internet)
  - Pay extra for bandwidth lease

Extras

Earth Stations Have...

- A view of the satellite we are talking on
- Terrestrial bandwidth
- Big enough antenna and amplifier to sustain carrier(s)
- Decent enough weather for the band
- Redundancy in power, data, etc
- Responsive staff

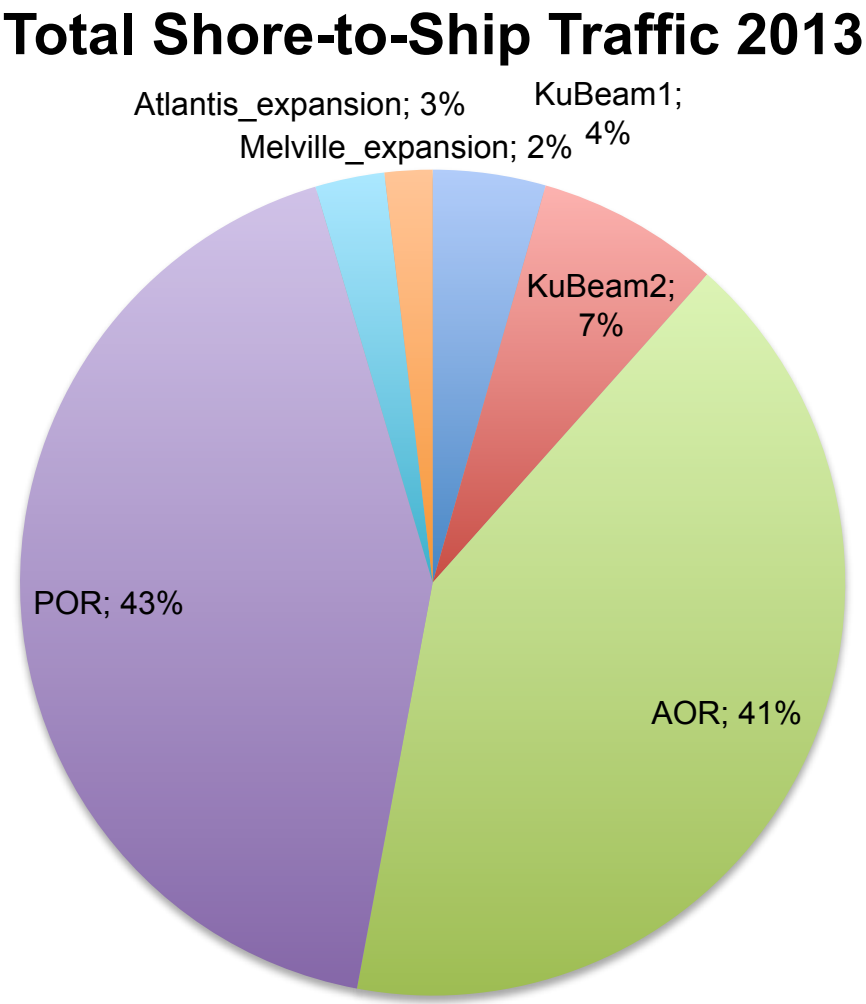
2013 HSN Shore-to-Ship Stats

Beam	Megabytes
N. Amer (Ku-band)	169,500
Gulf (Ku-band)	275,102
AOR (C-band)	1,586,320
POR (C-band)	1,629,421
Atlantis Expansion (C)	104,225
Melville Expansion (C)	71,729

2013 HSN Shore-to-Ship Stats

Totals **Totals**	**Megabytes**
Ku-band	444,603
C-band without expansion	3,215,740
C-band expansion	175,954

2013 HSN Usage



Rain Fade Attenuation

Rain Fade is the common term for Rain Attenuation. This attenuation (or signal strength loss) is caused by the absorption of the satellite signals by heavy rain.

Below is a chart that shows typical attenuation based on rain rate with the subject antenna set to a 30 degree elevation angle

Rain Attenuation (dB) at 30deg				
Rain Rate (mm/h)	4 GHz	6 GHz	12 GHz	14 GHz
5	.1	.15	1.6	1.8
10	.11	.80	2.0	2.9
15	.12	1.4	2.6	5.0
20	.13	1.6	3.3	6.8
25	.14	1.8	4.1	8.0
30	.15	2.0	5.0	9.2
35	.16	2.4	6.0	10.4
40	.17	2.8	7.0	11.8

Standard Satellite Frequency Bands

Band	Uplink Freq (GHz)	Downlink Freq (GHz)
C-Band	5.9-6.4	3.7-4.2
Ku-Band	14.0-14.5	11.7-12.2
Ka-Band	27.5-31.0	18.3-18.8 19.7-20.2

- Ku-band has many sub bands that are used differently in different places

Example Footprint