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 Global Xpress

**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 than 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
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
<table>
<thead>
<tr>
<th>Beam</th>
<th>Megabytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. Amer (Ku-band)</td>
<td>169,500</td>
</tr>
<tr>
<td>Gulf (Ku-band)</td>
<td>275,102</td>
</tr>
<tr>
<td>AOR (C-band)</td>
<td>1,586,320</td>
</tr>
<tr>
<td>POR (C-band)</td>
<td>1,629,421</td>
</tr>
<tr>
<td>Atlantis Expansion (C)</td>
<td>104,225</td>
</tr>
<tr>
<td>Melville Expansion (C)</td>
<td>71,729</td>
</tr>
</tbody>
</table>
## 2013 HSN Shore-to-Ship Stats

<table>
<thead>
<tr>
<th>Totals</th>
<th>Megabytes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ku-band</strong></td>
<td>444,603</td>
</tr>
<tr>
<td><strong>C-band without expansion</strong></td>
<td>3,215,740</td>
</tr>
<tr>
<td><strong>C-band expansion</strong></td>
<td>175,954</td>
</tr>
</tbody>
</table>
Total Shore-to-Ship Traffic 2013

- POR; 43%
- AOR; 41%
- KuBeam2; 7%
- KuBeam1; 4%
- Atlantis_expansion; 3%
- Melville_expansion; 2%
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.

<table>
<thead>
<tr>
<th>Rain Rate (mm/h)</th>
<th>4 GHz</th>
<th>6 GHz</th>
<th>12 GHz</th>
<th>14 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>.1</td>
<td>.15</td>
<td>1.6</td>
<td>1.8</td>
</tr>
<tr>
<td>10</td>
<td>.11</td>
<td>.80</td>
<td>2.0</td>
<td>2.9</td>
</tr>
<tr>
<td>15</td>
<td>.12</td>
<td>1.4</td>
<td>2.6</td>
<td>5.0</td>
</tr>
<tr>
<td>20</td>
<td>.13</td>
<td>1.6</td>
<td>3.3</td>
<td>6.8</td>
</tr>
<tr>
<td>25</td>
<td>.14</td>
<td>1.8</td>
<td>4.1</td>
<td>8.0</td>
</tr>
<tr>
<td>30</td>
<td>.15</td>
<td>2.0</td>
<td>5.0</td>
<td>9.2</td>
</tr>
<tr>
<td>35</td>
<td>.16</td>
<td>2.4</td>
<td>6.0</td>
<td>10.4</td>
</tr>
<tr>
<td>40</td>
<td>.17</td>
<td>2.8</td>
<td>7.0</td>
<td>11.8</td>
</tr>
</tbody>
</table>
Ku-band has many sub bands that are used differently in different places.

<table>
<thead>
<tr>
<th>Band</th>
<th>Uplink Freq (GHz)</th>
<th>Downlink Freq (GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-Band</td>
<td>5.9-6.4</td>
<td>3.7-4.2</td>
</tr>
<tr>
<td>Ku-Band</td>
<td>14.0-14.5</td>
<td>11.7-12.2</td>
</tr>
<tr>
<td>Ka-Band</td>
<td>27.5-31.0</td>
<td>18.3-18.8 19.7-20.2</td>
</tr>
</tbody>
</table>