The Satellite Economics – Beyond the Cost per MHz

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• Keep in mind what satellite brings to your business
Procuring a Satellite Service: The Full Story
## Procuring a Satellite Service: The Full Story

- **Alpha** and **Beta** are competing Mobile Network Operators.
- They both need satellite connectivity to support their operations.
- However, they have a very different procurement approach.

<table>
<thead>
<tr>
<th>Alpha</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Selects the satellite operator which has the lowest price per MHz.</td>
<td>1. Designs the satellite network taking into consideration equipment and bandwidth requirements.</td>
</tr>
<tr>
<td>2. Then, buys the cheapest equipment available on the market.</td>
<td>2. Performs a Total Cost of Ownership analysis including CAPEX and OPEX.</td>
</tr>
<tr>
<td>3. Doesn’t fully take into account future requirements in terms of equipment, coverage and bandwidth.</td>
<td>3. Considers future requirements to select an effective invest-as-you-grow solution.</td>
</tr>
<tr>
<td>4. Trains in-house satellite experts to keep optimizing the network</td>
<td></td>
</tr>
</tbody>
</table>
Procuring a Satellite Service: The Full Story

What could be the consequences of the two different approaches?

• An initial “cheap” design may prove to be more expensive over time:
  • Company Alpha may need to invest more than Beta to expand the network
  • With limitations of ground equipment, bandwidth-saving techniques can hardly be implemented.

• Possible lower performance
  • Service availability, satellite performance, technical support, … matter.

*Always compare apples with apples!*
## Procuring a Satellite Service: The Full Story

- Example with Alpha and Beta’s respective services:

<table>
<thead>
<tr>
<th></th>
<th>Alpha</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Information Rate</strong></td>
<td>10 x 1 Mbps</td>
<td>10 x 1 Mbps</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td>1.6 bps/Hz</td>
<td>2.8 bps/Hz</td>
</tr>
<tr>
<td><strong>Required bandwidth</strong></td>
<td>6.25 MHz</td>
<td>3.57 MHz</td>
</tr>
<tr>
<td><strong>Price $/MHz</strong></td>
<td>2,000 $/MHz*</td>
<td>2,500 $/MHz*</td>
</tr>
<tr>
<td><strong>Bandwidth MRC</strong></td>
<td>12,500 $/month</td>
<td>8,929 $/month</td>
</tr>
<tr>
<td><strong>Equipment investment</strong></td>
<td>100,000 $*</td>
<td>180,000 $*</td>
</tr>
<tr>
<td><strong>Contract length</strong></td>
<td>36 months</td>
<td>36 months</td>
</tr>
<tr>
<td><strong>Total Cost of Ownership</strong></td>
<td><strong>550,000 $</strong></td>
<td><strong>501,429 $</strong></td>
</tr>
<tr>
<td><strong>Equipment feature</strong></td>
<td>Entry-level modems, Modcod 8PSK 3/4, Roll-off factor 40%</td>
<td>Advanced modems with Carrier Cancellation Technique and ACM, Modcod QPSK 7/8, Roll-off 25%</td>
</tr>
<tr>
<td><strong>Satellite performance</strong></td>
<td>C-band global beam low EIRP</td>
<td>C-band zone beam high EIRP</td>
</tr>
</tbody>
</table>

*Indicative figures
Procuring a Satellite Service: The Full Story

• In addition to saving more money despite a higher initial investment:
  • Beta’s service reaches virtually 100% availability thanks to ACM (Adaptive Coding and Modulation)
  • Beta will require less bandwidth to increase the data rates, compared to Alpha → easier growth
  • Beta is more competitive in the market since its cost per Mbps is about 30% lower than Alpha’s
  • With the high performance satellite used by Beta, additional low-cost sites can be easily deployed with smaller antennas and less power.
The Cost Structure of a Satellite Network
The Cost Structure of a Satellite Network

• As seen in the previous example, several parameters must be considered
  - Equipment:
    • Antenna size
    • BUC size
    • Modem capabilities
  - Network topology:
    • Star or Mesh
  - Satellite bandwidth:
    • Performance of the satellite
    • Type of coverage: global, hemispheric, zone or spot beam
    • Dedicated or shared bandwidth
  - Other: license fees, installation, maintenance, international shipment, …

The performance requirements can significantly impact the network design thus the overall cost. Define them sensibly and be ready for tradeoffs!

The good design of a network will consider the investment and recurring costs required to meet the requirements, while taking into consideration scalability.
The Cost Structure of a Satellite Network

- A link budget report typically provides information that help assessing the cost of the solution.

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dakar to Bi, (15,000 Mbps, CH=0%)</td>
<td>5.714</td>
<td>1.46</td>
<td>8.000</td>
<td>24.3</td>
<td>11.8</td>
<td>12.9</td>
<td>7.6</td>
<td>8.7</td>
<td>99.96</td>
<td>66.6</td>
<td>65.4</td>
</tr>
<tr>
<td>Bi to Dakar, (15,000 Mbps, CH=0%)</td>
<td>5.714</td>
<td>1.46</td>
<td>8.000</td>
<td>21.0</td>
<td>11.8</td>
<td>13.1</td>
<td>7.6</td>
<td>8.9</td>
<td>99.96</td>
<td>63.0</td>
<td>37.8</td>
</tr>
</tbody>
</table>

- Carrier Information (depends on modem capabilities)
- Required Transponder Bandwidth Power (PEB)
- Designed Link Availability

<table>
<thead>
<tr>
<th>Antennas</th>
<th>Diameter [m]</th>
<th>TOTAL HPA Power [W]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bi</td>
<td>4.5</td>
<td>37.6</td>
</tr>
<tr>
<td>Dakar</td>
<td>8.0</td>
<td>55.4</td>
</tr>
</tbody>
</table>

- Antenna size and required BUC power

Satellite and Role: 10S-905 @ 335.50°E
Transponder: 104/104 (SE/SE)
Platform bias: -0.23°E; 0.00°N
Sat. TWT Power [Watts]: 61.8
Sat. D/L EIRP at 1 GHz [dBW]: 37.0 / 40.7
SFD at 1 GHz [dBW]: -73.6 / -83.1
Band Up/Dw [MHz]: (6184 - 6265) / (3959 - 4031)
Polarization Up/Dw: R / L

Intelsat
Comparison of Different Satellite Networks
Dedicated SCPC Links

- SCPC = Single Channel Per Carrier
- Typically used for point-to-point links with dedicated bandwidth
- Example of a network:
  - Dakar to Bamako: 2 Mbps
  - Dakar to Abidjan: 2 Mbps
  - Bamako to Dakar and Abidjan to Dakar: 1 Mbps each
  - All sites have a 2.4m antenna and entry-level modems.

For 99.96% availability
6.8 MHz are required for the total network

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Link 1</th>
<th>Link 2</th>
<th>Link 3</th>
<th>Link 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPSK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information Rate</td>
<td>2000.0</td>
<td>1000.0</td>
<td>2000.0</td>
<td>1000.0</td>
</tr>
<tr>
<td>FEC Code Rate</td>
<td>.7500</td>
<td>.7500</td>
<td>.7500</td>
<td>.7500</td>
</tr>
<tr>
<td>R-S Code Rate</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Clear Sky Eb/No Available</td>
<td>5.6</td>
<td>5.6</td>
<td>5.7</td>
<td>6.0</td>
</tr>
<tr>
<td>Number of Assigned Carriers</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Transmit ES Code</td>
<td>DAKAR</td>
<td>BAMAKO</td>
<td>DAKAR</td>
<td>ABIDJAN</td>
</tr>
<tr>
<td>Transmit ES Size</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Receive ES Code</td>
<td>BAMAKO</td>
<td>DAKAR</td>
<td>ABIDJAN</td>
<td>DAKAR</td>
</tr>
<tr>
<td>Receive ES Size</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Receive ES G/T</td>
<td>19.6</td>
<td>19.6</td>
<td>19.6</td>
<td>19.6</td>
</tr>
<tr>
<td>Coordination Limit Check</td>
<td>Passed</td>
<td>Passed</td>
<td>Passed</td>
<td>Passed</td>
</tr>
</tbody>
</table>

Efficiency is only 0.88 bps/Hz
Improving Efficiency with Better Equipment

- Same network as previously, but with different hardware configuration

<table>
<thead>
<tr>
<th>Antenna sizes</th>
<th>Modems</th>
<th>Bandwidth</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial network</td>
<td>2.4m Entry-level</td>
<td>6.8 MHz</td>
<td>0.88 bps/Hz</td>
</tr>
<tr>
<td>Larger antennas</td>
<td>3.7m Entry-level</td>
<td>4.8 MHz</td>
<td>1.25 bps/Hz</td>
</tr>
<tr>
<td>Lower roll-off factor</td>
<td>3.7m Advanced</td>
<td>4.3 MHz</td>
<td>1.40 bps/Hz</td>
</tr>
<tr>
<td>Carrier Cancellation Technique</td>
<td>3.7m Advanced with CCT</td>
<td>2.9 MHz</td>
<td>2.07 bps/Hz</td>
</tr>
</tbody>
</table>

- Now, if the requirements are modified a bit:
  - Using Adaptive Coding and Modulation (ACM) and Carrier Cancellation Technique
  - Maximum throughput 2 Mbps /1 Mbps (95% of the time)
  - Minimum throughput 1.6 Mbps /0.94 Mbps
  - Required bandwidth is 2.4 MHz and efficiency is 2.5 bps/Hz
Improving Efficiency with Better Equipment

• As seen in previous examples, using better equipment leads to higher efficiencies thus lower recurring costs.

• However:
  • Only a Total Cost of Ownership (TCO) analysis can determine whether the investment on hardware is worth the bandwidth savings
  • The size of the network, the required bandwidth and possible savings must be taken into consideration.
Not All Satellites are Equally Performant

The efficiency that can be achieved for a given satellite link also depends on the characteristics of the satellite and transponder:

- Power density and G/T
- Beam coverage:
  - The wider the beam, the larger the service area can be, but...
  - Wider beams (especially global beams) typically have lower power density
  - Note that some satellite operators only have global C-band beams for services in Africa
- Elevation angle: preferably above 20 degrees
- Available capacity

Intelsat’s EpicNG satellites represent a major step forward:

- High throughput, increased power density, flexibility, vendor-agnostic, etc.
Not All Satellites are Equally Performant

What about Ka-band? 1/2

- Ka-band is more susceptible to rain attenuation

Legend:
Link Margin required for 99.6% availability
Not All Satellites are Equally Performant

What about Ka-band? 2/2

- Most Ka-band spot beams are smaller than Ku-band beams: more beams required to cover an area
  - In an attempt to cover the globe, some operators are stretching their beams, which reduces their power and efficiency
- A few myths on Ka-band:
  - “Higher frequencies provide higher throughput”
    Myth: There is nothing fundamental in a frequency band which supports higher throughput
  - “Ka-band is more cost-effective because it allows us of smaller antennas”
    Myth: Higher frequencies result in greater path loss between the antenna and the satellite, which nullifies the increase in antenna performance. For similar link performance, larger Ka-band terminals are required
  - “Attenuation mitigating techniques can compensate Ka-band rain fade”
    Myth: There is a limit of how much rain fade ACM and UPC can address and these techniques are unlikely to be fully able to compensate for Ka-band rain fade.
  - “High Throughput Satellites (HTS) are Ka-band satellites”
    Myth: An HTS satellite is one that uses significant frequency reuse techniques to multiply the effective throughput capacity of the satellite. EpicNG HTS satellites use C-, Ku- and Ka-bands.
Sharing Resources for Better Cost Efficiency

• Dedicated SCPC links are well-suited to:
  • Connections that need to be up all the time
  • Traffic patterns that do not have dynamic variations

• Sharing resources:
  • Satellite bandwidth
  • Modulators and demodulators hub cards

• Solutions with shared resources are preferable when:
  • Network is large with a central hub: avoid having multiple modems at hub
  • Traffic demand is dynamic and varies within the network
Sharing Resources for Better Cost Efficiency

• Typical configuration:
  • Central hub with one or several modulator and demodulator cards
  • Remote sites equipped with modems and possibly DVB receivers
  • Shared outbound carrier (from hub to remotes), typically DVB-S2
  • Dedicated or shared inbound carriers (from remotes to hub):
    • TDMA, MF-TDMA, dSCPC, Mx-DMA

• Most equipment manufacturers have such solutions:
  • Comtech Heights, Newtec Dialog, iDirect Flex, Gilat SkyEdge, etc.
  • Intelsat offers solutions based on Newtec and iDirect hub equipment
Sharing Resources for Better Cost Efficiency

Intelsat’s platforms

- IntelsatOne® NBB Service
  - iDirect-based flexible and scalable platform.
  - Dedicated or Shared VNO offering
  - 55 hubs in 10 teleports
  - Typical dedicated configuration:
Sharing Resources for Better Cost Efficiency

*Intelsat’s platforms*

- New Shared NBB platform for Africa on IS-905

**Remote Kit Options:**
- Preferably: X1/X3/X5 modem + 2.4 m antenna with 5 W – 10 W BUC
- Option: X1/X3/X5 modem + 1.8 m antenna with 10 W BUC

**Available Throughput:**
- Forward: 30 Mbps → 74-84 Mbps IP rate
- Return: as required with following return carrier options (info rate at QPSK %):
  - 2.4 M 10 W 1.5 Mbps
  - 2.4 M 5 W 800 Kbps - 1 Mbps
  - 1.8 M 10 W 800 Kbps - 1 Mbps

**Platform Software Rev:** iDX 3.1.1.2

**Satellite Connectivity:**
- Forward: NW/SE. Shared carrier on a 36 MHz premium saturated transponder
- Return: SE/NW ~ as required
- Uplink: Mountainside teleport, USA

**Low TCO:** DVB-S2 with ACM forward link over saturated premium transponder to deliver lowest costs per Mbps and minimize remote kit sizing

**Shared physical network** per VNO with traffic segregation per VLAN and GQOS

**Committed CIR** with no oversubscription
Sharing Resources for Better Cost Efficiency

Intelsat’s platforms

• IntelsatOne® Internet Trunking Services
  • Dedicated Carrier (ITS-DC) or shared DVB service (ITS-DVB)

ITS-DVB coverage for Africa

• Shared DVB-S2 Forward Carrier with Committed Information Rates
• Dedicated SCPC return

Three DVB-SE hubs with US & Europe Connectivity
Sharing Resources for Better Cost Efficiency

*Intelsat platforms*

- Collocation Facilities at Teleports
  - Customer collocation facilities available at all teleports
    - Collocation capability at PoPs via PoP provider
  - Enables customization of basic transport services
  - Customer differentiation through addition of applications

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Carrier Grade Collocation Facilities
- 24/7 on-site manning for “remote hands”
- Multi-layer physical security control procedures
- Redundant, secure power
- Cooling and fire suppression
- Resilient telco-grade backbone network
Satellite Brings Benefits to Your Business!
Satellite Brings Benefits to Your Business

- Satellite technology should not be seen as last resort. It offers:
  - Unmatched reliability
  - Very high availability
  - Short service implementation time in remote areas
  - Wide coverage
  - Easy point-to-multipoint communications
  - Good value for money with state-of-the-art technology
  - Opportunities for growth in untapped rural markets
  - And so much more …
Conclusion
Conclusion

- Do not focus solely on unit prices for satellite capacity
- Always ask:
  - What is the satellite performance?
  - What equipment takes full benefit of the satellite capacity?
  - What network topology do I need for the service?
  - What efficiency can I reach?
  - What is the Total Cost of Ownership?
  - What support can I get from the satellite operator?
  - What revenues and benefits can I drive from this service?
Questions?