The Application of a Commercial Wideband Constellation for ISS Communications

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Based on Material Presented to NASA Lewis Research Center
Outline

• Review of Why Stations Comms Are Unique
• Overview of Previous Study Results
• Case for V-band MEO Consideration
• The ORBLINK System
• Application to ISS Communications
• Conclusions and Future Work
Unique Station Requirements

- **The ISS Is Not a Fixed Terrestrial Point**
  - This User Is Travelling ~7000 m/s With Respect to Other System Users
  - It Is About 400 Km Above Other System Users

- **The ISS Requires Service Over Both Land and Water**
  - This User Requires Continuous Coverage Over the Latitude Band Between 57 Deg. North and 57 Deg. South

- **The ISS Requires Service Up to 100 Mbps Uplink and 300 Mbps Downlink (TDRSS)**
  - This User Is One of the Most Data Intensive
  - More Bandwidth Would Be Welcome

For Almost All High Rate (FSS) Commercial Ka-band and Above Systems These Characteristics Would Force Significant Modifications
Previous Study\(^{(†)}\) Results (FSS Portion)

- Study Evaluated Wideband Commercial System Providers
- Concluded That None of the Examined Systems Support the Continuous High Bandwidth ISS Requirements
- Did Not Consider Any of the Proposed V-band Systems

\(^{(†)}\) ‘Assessment of Emerging Networks to Support Future NASA Space Operations’ By Badri Younes\(^{(1)}\), Roger Flaherty\(^{(1)}\), Susan Chang\(^{(2)}\), Ted Berman\(^{(2)}\), Mark Burns\(^{(2)}\), Robert Chang\(^{(2)}\) and Robert Lease\(^{(2)}\)

\(^{(1)}\) NASA/Goddard Space Flight Center  \(^{(2)}\) Stanford Telecom
### Ka-band to V-band Comparison

<table>
<thead>
<tr>
<th></th>
<th><strong>Ka-band</strong> ‘Bandwidth on Demand’</th>
<th><strong>V-band</strong> ‘Infrastructure on Demand’</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Service</strong></td>
<td>‘~T1 To The Home’ (1.544 Mbps Level)</td>
<td>‘Bulk Data Backhaul’ (10’s to 100’s Mbps)</td>
</tr>
<tr>
<td><strong>User Base</strong></td>
<td>ROM hundreds of 1000’s</td>
<td>ROM 1000’s</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>Broad Areas, Significant % of Land Mass Covered</td>
<td>Select ‘Data Intense’ Areas, % of Land Mass Covered Smaller</td>
</tr>
<tr>
<td><strong>Comments</strong></td>
<td>Some Systems Plan To Offer Specialized High Rate ‘Gateway’ Service (Up To OC12 For Teledesic/Celestri) But This Is Not Primary Focus</td>
<td>Small Beams Result From Increase In Carrier Frequency And Gain Required To Fight More Severe Rain Fade</td>
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</tbody>
</table>

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**Qualitatively Suggests That V-band Systems Will Have Primary Focus on Users With Rates More Comparable to Station Needs And Deliver This ‘Bulk’ Service at Reduced Cost/bit**

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**Q/V and Ka Systems Compared: Data per Dollar**

Source: FCC Filings
• V-Band Commercial Communications System (38 GHz D/L and 48.2 GHz U/L)
  – Primary Services Are 1) 1.244 Gbps ‘Data Backhaul’
  2) 10 to 51.84 Mbps ‘Wideband’

• 7 Satellite Constellation in a 9000 Km Equatorial Orbit (Plus One Spare)
  – Latency of ~1/16 S
  – Achieves Coverage of 93% of Population at Min. Elevation of 10 Deg.
  – Leverages System Power Over GEO’s for Better Capacity to Cost Ratio
  – Avoids LEO Complexity and Size

• Deployment Over 2003-4
  – NovaStar Adaptation
  – Orbital’s End-to-end Ability
ORBLINK Baseline: Architecture

“Ring of Bandwidth”
“Infrastructure On Demand”

7 Gbps
ISL
(13000 km)

Each of 7 Equatorial Satellites form 100 Tracking Beams, 20 for Backhaul and 80 for Wideband

Backhaul User @ 1.2 Gbps, one per beam

Wideband User @ 10 to 51.84 Mbps, ~50 per beam
Baseline ORBLINK Covers ISS 58.3% of the Time (Gold = Covered, Blue = Out of Beam-Form Cone)
A Small Increase In Beam Forming Cone Size Increases ISS-ORBLINK Availability To 100%
## Results Summary

500 km User, 57.0º Inclination

<table>
<thead>
<tr>
<th></th>
<th>Cyberstar</th>
<th>Spaceway</th>
<th>Teledesic</th>
<th>Orblink²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constellation Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constellation Orbit</td>
<td>GEO</td>
<td>GEO</td>
<td>LEO</td>
<td>MEO</td>
</tr>
<tr>
<td>Data Rate</td>
<td>3.1 Mbps</td>
<td>6.3 Mbps</td>
<td>2.1 Mbps</td>
<td>1.244 Gbps</td>
</tr>
<tr>
<td><strong>Communications Coverage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Service Duration/Orbit</td>
<td>Land Coverage¹</td>
<td>44.4 minutes</td>
<td>1.1 minutes</td>
<td>Total</td>
</tr>
<tr>
<td>Maximum Null Time</td>
<td>Land Coverage¹</td>
<td>47.1 minutes</td>
<td>&gt; 1 orbit</td>
<td>None</td>
</tr>
<tr>
<td>Maximum Data Throughput/Day</td>
<td>Land Coverage¹</td>
<td>254.9 Gbits</td>
<td>2.10 Gbits</td>
<td>7062 Gbits</td>
</tr>
<tr>
<td><strong>User Terminal Requirements</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required EIRP</td>
<td>48.73 dBW</td>
<td>48.55 dBW</td>
<td>33.23 dBW</td>
<td>62.30 dBW</td>
</tr>
<tr>
<td>Required G/T</td>
<td>19.33 dB/K</td>
<td>25.95 dB/K</td>
<td>8.13 dB/K</td>
<td>36.0 dB/K</td>
</tr>
</tbody>
</table>

1.  Not evaluated due to limited geometric coverage
2.  Table presented in previous study but with Orblink results added

**ORBLINK Can Meet ISS’s Need for Continuous and High Bandwidth Communications**
Conclusions

**ORBLINK Offerings to ISS:**
- Low Modification and Low Cost Commercial Communications System Solution
- OC-24 Link That Effectively Removes Bandwidth Constraints on ISS Operation
- High Quality Service
  - Low BER
  - Low Latency
  - 100% Availability

**Future Work:**
- Consider Other NGSO V-band Systems That May Require Low Modification to Support ISS Requirements

ORBLINK Offers ISS A Lower Cost and High Quality ‘Fiber Optic to Orbit’ Service