C-Band Testing
NAWCAD Patuxent River, MD

Presented to:
ITEA

Presented by:
Bruce Johnson & Dennis Normyle
Overview

- Airborne TM Goals
- Purpose of Test
- UH-60 TM System
- Flight Test Methodology
- Flight Test Data
- Answers to Questions
- Conclusions
- Path Forward
“1 Test = 1000 Expert Opinions”
Airborne Telemetry System Goals

• Design a system for maximum flexibility
  – Single transmitter capable of (L/S/C) band
  – Form fit replacement for legacy aircraft TM transmitters
  – Multiband low-loss cable (L/S/C)
  – Multiband antennas (L/S/C)

• No aircraft modification (downtime) required to move between the L, S and C bands
Purpose of Testing

• Answer the following questions:
  • How will C-band perform compared to L-band in a UH-60 at PAX?
  • How will C-band perform over the water?
  • How do multiband antennas perform compared to dedicated band specific antennas?

• Gather flight test data to convince reluctant Telemetry (TM) users to consider moving to the C-band

• Utilize network transceiver to adjust the center frequency on the C-band transmitter
  – Reduce the number of dedicated flights required to complete C- versus L-band testing
Transmitters

90/10 Splitters

C-band Xmtr

L/S-band Xmtr
Configurable Lower Antennas

L-band

Multiband (Used for L)

S-band

C-band

Multiband (Used for C)
UH-60 Flight Test Methodology

- Three (3) aircraft antenna configurations
- Repeat all test points in each configuration
  - Test three (3) C-band frequencies with dedicated C-band antenna
- Utilize network transceiver to change C-band transmitter center frequency

<table>
<thead>
<tr>
<th>Configuration # 1</th>
<th>Dedicated L-band Antenna</th>
<th>Dedicated C-band Antenna</th>
<th>Network Transceiver</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flights 7/26, 7/28, 8/8, 8/10</strong></td>
<td>Freq: 1449.5Mhz All Test Points</td>
<td>Freq: 4490 Mhz (All Test Points) Freq: 4710 mhz (All Test Points) Freq: 4930 Mhz (All Test Points)</td>
<td>Freq: 2381.5 Mhz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Configuration # 2</th>
<th>Multiband Antenna</th>
<th>Dedicated C-band Antenna</th>
<th>Network Transceiver</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flight 8/11</strong></td>
<td>Freq: 1470.5 Mhz</td>
<td>Freq: 4710 mhz (All Test Points)</td>
<td>Freq: 2381.5 Mhz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Configuration # 3</th>
<th>Multiband Antenna</th>
<th>Multiband Antenna</th>
<th>Network Transceiver</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flight 8/12</strong></td>
<td>Freq: 1470.5Mhz</td>
<td>Freq: 4710 mhz (All Test Points)</td>
<td>Freq: 2381.5 Mhz</td>
</tr>
</tbody>
</table>
Hover 360 Degree Pedal Turn
• 50 – 400 feet
• 3 airfield locations
Antenna Patterns

- 360 Pedal Turn
- Maintaining Altitude & Look Angle

<table>
<thead>
<tr>
<th>Look Angle (degrees)</th>
<th>Ground Distance (feet)</th>
<th>Altitude (feet AGL above antennae)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>5870</td>
<td>1570</td>
</tr>
<tr>
<td>30</td>
<td>5260</td>
<td>3040</td>
</tr>
<tr>
<td>45</td>
<td>4300</td>
<td>4300</td>
</tr>
<tr>
<td>60</td>
<td>3040</td>
<td>5260</td>
</tr>
</tbody>
</table>
• Steep Approach/Climb out
  – 0 – 2000 feet
• Range Evaluation
  – 1500 – 5000 feet
  – 60 Miles
Tri-Band Antenna

- Antenna optimized for the C-band
- Max range Eb/No differences between the C- and L-band are negligible

<table>
<thead>
<tr>
<th>Frequency</th>
<th>RHCP G/T</th>
<th>LHCP G/T</th>
<th>Vertical</th>
<th>Horizontal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1435</td>
<td>3.804</td>
<td>4.361</td>
<td>3.517</td>
<td>4.497</td>
</tr>
<tr>
<td>1535</td>
<td>5.94</td>
<td>5.284</td>
<td>5.549</td>
<td>6.822</td>
</tr>
<tr>
<td>1700</td>
<td>7.483</td>
<td>7.794</td>
<td>9.163</td>
<td>9.511</td>
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<tr>
<td>1800</td>
<td>7.798</td>
<td>7.922</td>
<td>9.133</td>
<td>9.486</td>
</tr>
<tr>
<td>2200</td>
<td>7.731</td>
<td>11.838</td>
<td>7.918</td>
<td>12.628</td>
</tr>
<tr>
<td>4940</td>
<td>13.719</td>
<td>13.977</td>
<td>15.098</td>
<td>15.58</td>
</tr>
<tr>
<td>5120</td>
<td>14.244</td>
<td>14.63</td>
<td>15.256</td>
<td>15.624</td>
</tr>
</tbody>
</table>
Antenna Locations

- Antenna locations relative to airfield and range evaluation test points

Building 1592 antenna used for data. Secondary as backup.
Flight Summary

• Six flights

• Total of 11.5 hours

• Completed 114 dedicated test points

• 40,348 time history plots possible
## Data Quality Metrics

### Average over all test points for whole flight

<table>
<thead>
<tr>
<th>Flight Date</th>
<th>% Frame Syncs Captured L-band</th>
<th>% Frame Syncs Captured C-band</th>
<th>Signal Strength dB L-band</th>
<th>Signal Strength dB C-band</th>
<th>A/C Antenna Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 26th</td>
<td>98</td>
<td>95</td>
<td></td>
<td></td>
<td>Dedicated L, C</td>
</tr>
<tr>
<td>July 28th</td>
<td>91</td>
<td>91</td>
<td>49</td>
<td>46</td>
<td>Dedicated L,C</td>
</tr>
<tr>
<td>Aug 8th</td>
<td>96</td>
<td>94</td>
<td>53</td>
<td>52</td>
<td>Dedicated L, C</td>
</tr>
<tr>
<td>Aug 10th</td>
<td>92</td>
<td>94</td>
<td>35</td>
<td>48</td>
<td>Dedicated L,C</td>
</tr>
<tr>
<td>Aug 11th</td>
<td>87</td>
<td>96</td>
<td>41</td>
<td>44</td>
<td>Multi L Dedicated C</td>
</tr>
<tr>
<td>Aug 12th</td>
<td>92</td>
<td>98</td>
<td>58</td>
<td>47</td>
<td>Multi L,C</td>
</tr>
</tbody>
</table>
Dedicated L & C Antennas
360 Deg Hover Turn

Heading

Pedal Position

1449.5 L-band
4490 C-band MHz

1449.5 L-band
4710 C-band MHz

1449.5 L-band
4930 C-band MHz
Range Evaluation
Dedicated L / Dedicated C

- 1449.5 L-band
- 4710 C-band

~60 NM
Points of Interest
Changing C-Band Center Freq using Network Transceiver

Frequency Change to 4710.5
Questions and Answers

1. How does the performance of C-band compare to L-band in a UH-60 at Patuxent River?
   - C-band and L-band performance is similar for airfield test points.
   - C-band frequencies compared favorably to lower L-band on the range evaluation.
Answers to Questions

• How will C-band perform over the water?
  • *C-band over water performed well using antenna located at airfield*
  • *Sea states were very low*
  • *Next tests will use Point Lookout antenna for better look over water*
  • *Further investigation is needed*
Answers to Questions

• How do multiband antennas perform compared to dedicated band-specific antennas?
  
  • Similar performance in the L- and C-bands for airfield test points
  
  • Degradation in signal quality in both the L- and C-bands during range evaluation test points
    • C-band performed better than L-band
    • Based on antenna plots this was not expected
  
  • Further investigation is needed.
Summary/Conclusions

- Nick Wirz, Test Conductor
  “Using C-Band, no knock-it-off calls would have been given during representative Rotary Wing test points.”

- C-band doesn’t like trees. Significant loss of signal compared to L-band with obstructed views. This is an issue at PAX. Analysis continuing.

- C-band and L-band both lost data at relatively the same time but behavior was slightly different. Investigations continue.

- Multiband cable performed well as expected based on calculations, and lab tests compared to flight test results.
C-band TM is effective for typical helicopter test points at Patuxent River
Path Forward

• Target new installations for C-band use
  – V-22 upgrades
  – CH-53K
• Instrument TPS F/A-18F test bed with S- and C-band transmitters with a network transceiver
• Brief flight test community on these results
  – Obtain flight test buy-in to target specific legacy aircraft for C-band use
Contact Information

Bruce Johnson
Aircraft Instrumentation
Phone: (301) 342-3816
Email: bruce.johnson@navy.mil

Dennis Normyle
Real-Time Telemetry
Phone: (301) 342-8744
Email: dennis.normyle@navy.mil