Hybrid TV-GPS positioning

11/06/07
Guttorm Opshaug Ph.D.
Broadcast TV Provides Indoor, Urban Visibility

Advantages of TV over GPS:

- High Power
  1MW ERP typical (1000x GPS)
- Low Frequency
  54-800 MHz (stronger indoor signals)
- Horizontal Signals
  Less attenuation from walls than roofs
- Frequency Diversity
  Clear 6MHz channels, multiple channels per tower
- Vertical Signals
  Greater attenuation from roofs and floors

Technology Background:

- Low Power
  500W ERP
- High Frequency
  1.575GHz
- Limited Spectrum
  Single shared frequency
- Horizontal Signals
  Less attenuation from walls than roofs

~40 dB (10,000X) indoor power advantage
TV+GPS Hybrid Positioning Module

- Available as of October 2006
- Integrates TV-positioning with A-GPS at pseudoranging level
- Rosum assists A-GPS
- Delivers 30-50m indoor accuracy
- Focus on safety-of-life applications
- 58 million people under coverage
Wide-Area Testing: FCC Compliance Testing

E 9-1-1 requirements for handset-based location technologies

67% of all fixes must be less than 50m from ground truth
95% of all fixes must be less than 150m from ground truth

Why use the FCC Guidelines?
• Widely accepted and understood accuracy metrics
• Challenging in environments where GPS is unreliable

Why exceed testing requirements?
• No indoor testing required (5% recommended by other org.)
• Recent FCC statements (NPRM) address poor performance of E9-1-1 location technologies
• People spend much of their time indoors
• New communications technologies (VoIP, Femtocells) require reliable in-building location and timing
Wide-Area Testing: FCC Compliance Testing

Our Test:

• Conducted by 4G communications, an independent 3rd-party
• Testing was done according to OET-71 guidelines (FCC doc)
• 30 sites/metro area
• At least 1200 total fixes/metro area
  • 50% of all test sites (and about 50% of the fixes) done outdoors,
  • 50% of all test sites (and about 50% of the fixes) done indoors
• Indoor locations were chosen to meet the ATIS0500011 guidelines
  (which force you to test in meaningful, sometimes nasty, indoor locations)
## Wide-Area Testing: FCC Compliance Testing

<table>
<thead>
<tr>
<th>Metro Area</th>
<th>Overall</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Santa Clara, CA</td>
<td>67%</td>
<td>95%</td>
<td>67%</td>
<td>95%</td>
<td>67%</td>
</tr>
<tr>
<td>Nashua, NH</td>
<td>31</td>
<td>66</td>
<td>39</td>
<td>71</td>
<td>22</td>
</tr>
<tr>
<td>Needham, MA</td>
<td>33</td>
<td>63</td>
<td>34</td>
<td>59</td>
<td>33</td>
</tr>
<tr>
<td>Edison, NJ</td>
<td>50</td>
<td>83</td>
<td>54</td>
<td>97</td>
<td>45</td>
</tr>
<tr>
<td>Washington, DC</td>
<td>49</td>
<td>86</td>
<td>46</td>
<td>80</td>
<td>49</td>
</tr>
</tbody>
</table>

Rosum E911 Compliance Testing – Results (Meters)
Rosum Beacons

- TV-UHF band (470-800 MHz)
- 10 Watts EIRP
- TV-like signal
  - 6 MHz Bandwidth
  - 8-VSB modulation
  - PN511 M-code (ATSC)
- Coax-tethered prototype with single source of base-band signal generation
- 8 RF-channels of transmission
What’s on TV?

Never lost with The PN511 show!

ATSC has 0.2% Duty Factor

Beacon signal is repeating PN511 sequence with 100% Duty Factor
Frequency Diversity at Beacon

- Two frequencies per Beacon
Antenna Diversity at Receiver
Beacon System
PTT Field test results

<table>
<thead>
<tr>
<th>Test *</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>67%</td>
<td>3.1</td>
<td>2.8</td>
<td>5.6</td>
<td>3.0</td>
<td>6.8</td>
<td>6.6</td>
<td>10.4</td>
<td>2.5</td>
<td>2.8</td>
<td>8.0</td>
<td>5.1</td>
<td>3.5</td>
<td>4.3</td>
</tr>
<tr>
<td>95%</td>
<td>6.2</td>
<td>28.2</td>
<td>8.3</td>
<td>4.0</td>
<td>11.1</td>
<td>8.5</td>
<td>27.6</td>
<td>6.0</td>
<td>5.2</td>
<td>19.9</td>
<td>8.0</td>
<td>6.2</td>
<td>8.2</td>
</tr>
<tr>
<td>Yield</td>
<td>100%</td>
<td>96%</td>
<td>99%</td>
<td>100%</td>
<td>97%</td>
<td>100%</td>
<td>86%</td>
<td>100%</td>
<td>100%</td>
<td>98%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Conclusion

- **Wide-Area System**
  - Metro-regional coverage
  - 30-50m accuracy
  - Situational awareness

- **Beacons**
  - Fixed or mobile
  - Stand-alone or Wide-Area augmentation
  - 3-10m accuracy
  - Tactical awareness
Thanks!
Rosum Wide-Area Positioning
FCC: For handset-based location technologies

- 67% of all fixes must be less than 50m from ground truth
- 95% of all fixes must be less than 150m from ground truth