S32-4: AHG on Core Broadcast Services - Progress Report

Jim Kutzner,
S32-4 Chairman
PBS
Activities of S32-4

- Developed C/N Bit-Rate Calculator
  - Determine expected C/N performance at various settings
    - TDM-only & TDM-LDM combination
- Developed Use Case Calculator
  - Urban/Suburban terrains
  - Outdoor/Indoor/Pedestrian/Mobile environments
- Developing Example Coverage Maps
  - Various markets under various conditions
Multiple Operating Points (AWGN)

- Shannon
- ATSC 3.0
- DVB-T2
- A/53
- A/153

- Low Capacity, More Robust
- High Capacity, Less Robust

Link BICM Efficiency (bits/sec/Hz) vs. SNR (dB)

A/53
A/153
Shannon Limit

(few operating points)
(one operating point)
<table>
<thead>
<tr>
<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>
</tr>
</thead>
<tbody>
<tr>
<td>BW</td>
<td>FFT</td>
<td>GI</td>
<td>Dc</td>
<td>Dy</td>
<td>QAM</td>
<td>LDPC</td>
<td>$P_c$</td>
<td>$P_r$</td>
<td>Injection level</td>
</tr>
<tr>
<td>6</td>
<td>16S84</td>
<td>20</td>
<td>2.388-03</td>
<td>0.0094</td>
<td>0.0412</td>
<td>0.0031</td>
<td>0.0031</td>
<td>0.0031</td>
<td>0.0031</td>
</tr>
</tbody>
</table>

**Pick:**
- BW
- FFT Size
- Guard Interval
- Scattered Pilot frequency spacing
- Scattered Pilot time spacing
- Constellation size
- LDPC length
- LDPC code rate
- BCH on/off
- Frame duration
- Lower level injection level
C/N Calculator - output

Pay load

<table>
<thead>
<tr>
<th></th>
<th>AA</th>
<th>AB</th>
<th>AC</th>
<th>AD</th>
<th>AE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full channel bits per second</td>
<td>4,062,454</td>
<td>16,280,134</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AWGN SNR dB</td>
<td>2.79</td>
<td>15.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rayleigh SNR dB</td>
<td>5.20</td>
<td>18.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doppler speed, kph @695 Mhz</td>
<td>183.6</td>
<td>153.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doppler speed, mph @695 Mhz</td>
<td>114.1</td>
<td>95.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LDM – Upper Layer
LDM – Lower Layer
C/N Calculator ("function generator")

Transmit Settings → C/N Calculator → Expected C/N Performance

→ C/N Calculator ←
<table>
<thead>
<tr>
<th>Type</th>
<th>Parameter</th>
<th>Units</th>
<th>Calculated Scenario</th>
<th>Actual Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shortfall</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Daytime</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nighttime</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>General</td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**
- Add comments as needed for each scenario.
- Ensure consistency across all calculated parameters.
- Review and validate all calculations for accuracy.

**Additional Details:**
- Use Table A17-1: Use Case Scenario Details for reference.
- Ensure all parameters are up-to-date and relevant.

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**Handbook of Land-Mobile Radio System Coverage**

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**References:**
- [Tune In to the Future](#)
# Coverage Use Case Spreadsheet

**Included sheets:**
- Upper and lower end of bands:
  - VHF – Low band
  - VHF – High band
  - UHF – Ch. 14-36
- Reference charts
- Use Case Users’ Guide

<table>
<thead>
<tr>
<th>Type</th>
<th>Parameter</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Frequency</td>
<td>MHz</td>
</tr>
<tr>
<td>System</td>
<td>RF Allocated Bandwidth</td>
<td>MHz</td>
</tr>
<tr>
<td>System</td>
<td>ERP</td>
<td>watts</td>
</tr>
<tr>
<td>System</td>
<td>Required C/(N+1) w Short Term Fading Margin</td>
<td>dB</td>
</tr>
<tr>
<td>System</td>
<td>Transmit Height (HAAT)</td>
<td>m</td>
</tr>
<tr>
<td>System</td>
<td>Receive Height</td>
<td>m</td>
</tr>
<tr>
<td>Calculated</td>
<td>EIRP</td>
<td>dBm</td>
</tr>
<tr>
<td>Planning</td>
<td>Mean Penetration Loss</td>
<td>dB</td>
</tr>
<tr>
<td>Planning</td>
<td>Std Dev Building Penetration</td>
<td>dB</td>
</tr>
<tr>
<td>Planning</td>
<td>Outdoor Std. Dev. Log Normal Shadowing by Location</td>
<td>dB</td>
</tr>
<tr>
<td>Planning</td>
<td>Edge of Coverage Reliability for 95% Area</td>
<td>%</td>
</tr>
<tr>
<td>Planning</td>
<td>SFN Gain due to Path Diversity, if SFN</td>
<td>dB</td>
</tr>
<tr>
<td>Calculated</td>
<td>Hata Davidson Model Morphology</td>
<td></td>
</tr>
<tr>
<td>Calculated</td>
<td>Time Fade Margin</td>
<td>dB</td>
</tr>
<tr>
<td>Calculated</td>
<td>Total Standard Deviation Indoor and Outdoor</td>
<td>dB</td>
</tr>
<tr>
<td>Calculated</td>
<td>Margin for Std Deviation of Losses</td>
<td>dB</td>
</tr>
<tr>
<td>Calculated</td>
<td>Total Link Margin</td>
<td>dB</td>
</tr>
</tbody>
</table>
Multiple Operating Points (AWGN)

- Shannon
- ATSC 3.0
- DVB-T2
- ★ A/53
- ★ A/153

TDM can operate anywhere along the curve (with single or multiple Physical Layer Pipes [PLPs])

LDM (two layers illustrated) also operating along the curve
Maps!: Creation Tools Used

- EDX
  - multiple tools and options
- Splat!
  - Open source, Linux based
  - Following coverage plots created using Splat!
- V-Soft
  - easy to use for broadcast, multiple propagation models and options
Caveat: These are only examples!

- The following coverage plots and associated data are illustrations of what the ATSC 3.0 system could do.
- Many existing tower sites and antennas were used but no frequency searches or interference studies were made.
- Studies were done using Longley-Rice.
  - But at 95-90 and receive height of 4 meters.
S32-4 Project Includes:

- Washington, DC Area
  - UHF & VHF
- San Francisco
  - Difficult Terrain
- Atlanta, GA
  - Mid-level Terrain
- Iowa Public Television
  - Individual stations & State-wide SFN
DC - WRC-DT (ATSC 3.0 1 MW ERP on Ch. 36)
DC – Adding SFN Combined Power (RSS)
DC – Adding SFN Combined Power (RSS) (closeup)
## Combined Service → More People

<table>
<thead>
<tr>
<th>Condition</th>
<th>Population @ 80 dBµV/meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single transmitter (DC)</td>
<td>2,819,869</td>
</tr>
<tr>
<td>Combined (all five transmitters)</td>
<td>4,596,775</td>
</tr>
<tr>
<td>Percent gain:</td>
<td>63%</td>
</tr>
<tr>
<td>Population served by exactly two transmitters:</td>
<td>246,442</td>
</tr>
<tr>
<td>Population served by exactly three transmitters:</td>
<td>1,497,278</td>
</tr>
<tr>
<td>Population served by exactly four transmitters:</td>
<td>1,763,638</td>
</tr>
<tr>
<td>Population served by exactly five transmitters:</td>
<td>1,017,223</td>
</tr>
</tbody>
</table>
DC – Strongest Server
DC - Number of servers
Example:
Iowa SFN
Ch. 36
LR F(95,90)
4m Rx. Ht.
Multiple Operating Points (AWGN)

Shannon
ATSC 3.0
DVB-T2
A/53
A/153

Link BICM Efficiency (bits/sec/Hz)

SNR (dB)

Demonstrates that with ATSC 3.0, by adding SFN transmitters you can raise the SNR at the receiver and "move up" on the Shannon curve – thus adding capacity.

LDM will allow reception at lower SNR in more challenging environments with less impact on total channel capacity.
Longley-Rice vs. other models

• LR is a terrain-sensitive tool useful over large areas
• Other models such as Hata-Davidson are more useful for urban clutter
• We need to use both models
• For now: subtracting 6-9 dB from a LR model will yield more realistic performance in urban areas
Summary: ATSC 3.0 will provide:

- Many modulation setting options to tailor the broadcast for specific business opportunities
  - Balance robustness and payload capacity
- SFN options to shape coverage and fill in difficult areas for realistic fixed and mobile services
  - Ability to better shape the coverage areas
- Many tools will be available to aid in decisions
How does migrating to ATSC 3.0 advantage me, the broadcaster?

- Provides me the ability to receive off-air on hand-held devices deep indoors
- Provides me the ability to provide a significant number of multicast services (UHD/HD/SD)
- Provides me the ability to change the characteristics of my distribution system as my business plan changes
  - Provides me the agility to react to changing markets
Questions?
ATSC 3.0
TV. Mobile. Everywhere.

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