NATIONAL PUBLIC RADIO

Final Report to the Corporation for Public Broadcasting

Digital Radio Coverage & Interference Analysis (DRCIA) Research Project

EXECUTIVE SUMMARY

July 9, 2008
CPB Account No. 10446

npr labs

Digital Radio Coverage & Interference Analysis (DRCIA) Research Project

Conducted by NPR Labs in partnership with, and support from,
the Corporation for Public Broadcasting

DRCIA Final Report – Executive Summary

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Digital Radio Coverage & Interference Analysis (DRCIA) Research Project

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Executive Summary

NPR, through the Corporation for Public Broadcasting (CPB) - funded Digital Radio Coverage and Interference Analysis (DRCIA) project, examined the coverage capabilities and impact of in-band on-channel digital audio broadcasting (IBOC DAB) in the United States. IBOC DAB holds great potential for public radio as these stations enter into a digital transmission era. As of this report's date, some 380 public radio stations are broadcasting in digital, providing over 500 digital program streams from over 130 multicasters, of whom over three dozen are triple-casting.

Since this digital transmission system may be added to existing broadcast stations in the FM band (and AM as well), CPB created the DRCIA project for three primary goals: to determine the coverage capabilities of (1) legacy analog FM service and (2) IBOC DAB service, and (3) evaluate the impact of the digital transmission system on reception of analog FM service, assuming all stations are operating in hybrid mode. CPB commissioned NPR Labs (which enlisted experts from other organizations on a subcontract basis) to conduct an extensive study of these issues. This study was recommended by the Digital Consultancy in 2005, was carefully designed by CPB and NPR to answer these questions, and was launched in late 2006.

As described in the full report, available at www.nprlabs.org, NPR Labs, led by project director and Senior Technologist John Kean, performed detailed receiver performance testing that was validated by carefully selected field tests. The analog receiver performance data was used to develop maps predicting, for the first time, actual coverage available to public radio listeners. Drawing on tests of digital receivers, NPR Labs spent a year painstakingly developing the first field-corroborated coverage prediction algorithm for IBOC DAB. This yielded more firsts: maps of public radio station coverage assuming all stations are operating in hybrid mode, for both their digital and analog services.

As summarized below, all 850 public radio stations were mapped for three types of reception with analog and digital service using a total of five interference-limited coverage scenarios:

<table>
<tr><th></th><th colspan="3">Analog Coverage Maps</th><th colspan="3">Digital Coverage Maps</th></tr>
<tr><td rowspan="2">Studies of 850 public radio stations</td><td>Mobile</td><td>Indoor</td><td>Portable</td><td>Mobile</td><td>Indoor</td><td>Portable</td></tr>
<tr><td colspan="3">Analog-only</td><td colspan="3">IBOC DAB at 1% power</td></tr>
<tr><td rowspan="4">Detailed studies of 75 sample stations</td><td>Mobile</td><td>Indoor</td><td>Portable</td><td>Mobile</td><td>Indoor</td><td>Portable</td></tr>
<tr><td colspan="3">Analog-only</td><td colspan="3">IBOC DAB at 1% power</td></tr>
<tr><td colspan="3">Analog with 1% IBOC on all stations</td><td colspan="3" rowspan="2">IBOC DAB at 10% power</td></tr>
<tr><td colspan="3">Analog with 10% IBOC on all stations</td></tr>
</table>

It is notable that the coverage maps for this study are not based on standardized values, like most coverage maps. The DRCIA maps have been created from actual receiver-derived measurements of stereo sensitivity and interference susceptibility, combined with practical receiving antenna efficiencies, building attenuation loss estimates and other factors to determine coverage. A calibrated point-to-point pathloss model was used to create terrain-sensitive coverage predictions. To represent typical vehicular, residential and portable reception, field strengths were determined at a receiving height of 1.5 meters (5 feet) above ground.

A set of 75 stations were selected to evaluate the key study goals. Two-thirds of these stations were selected from the 50 largest radio markets to represent the majority of the public radio system, while 25 additional stations were selected from smaller markets that provide substantial service to an outlying population. The set was analyzed in detail and population was counted for listener and economic evaluations.

The following summarizes key technical results of this study:

- With 1% IBOC transmission power operating on all stations:
    - Mobile IBOC DAB coverage would be 85% of quality analog coverage, by population, for the 50 sample stations.
    - Mobile analog FM population would be reduced an average of 14% for the sample stations due to interference from IBOC DAB. This affects most stations in varying degrees in outlying portions of their mobile analog service area.
- With 1% IBOC transmission power:
    - Indoor IBOC DAB service covers approximately 38% of the population served by analog with a large (83%) standard deviation. Results for portables are similar.
    - Analog FM indoor covered population would be reduced by IBOC interference an average of 6% for the sample stations. Interference to portable analog service is minimal. These relatively small impacts are due the higher field strengths required to receive the digital signal.
- With 10% IBOC transmission power:
    - Mobile IBOC DAB coverage would average 117% of quality analog coverage, by population, for all 50 sample stations.
    - Mobile analog FM covered population would be reduced an average of 26% for the sample stations. Interference would affect some stations severely in portions of their analog mobile service area: 41% could lose one-third or more of their covered population and 18% would lose more than half of their population.
- With 10% IBOC transmission power:
    - Indoor and portable IBOC DAB covered population totals would be 83% and 81% of analog coverage, respectively.
    - Analog FM indoor and portable covered population totals are reduced by 22% and 6%, respectively. Interference would affect some stations severely in portions of their analog indoor service area: 27% could lose one-third or more of their covered population and 16% could lose more than half of their population. Due to higher required field strengths to overcome low receive antenna efficiencies, indoor portable

reception is relatively slight: only 6% of stations are predicted to receive analog portable interference exceeding one-third of their analog-only covered population.

NPR Labs' general conclusions of the study results are:

- At the current 1% IBOC power, mobile digital coverage only slightly underperforms quality analog coverage, while indoor and portable digital coverage is substantially smaller than analog for most stations.
- Station impacts from IBOC DAB to analog FM vary widely from station to station, primarily due to the fact that the IBOC DAB digital sidebands are actually co-channel to neighboring stations on first-adjacent channels; the FCC's first-adjacent allocation rules for analog FM cannot adequately protect against some close-spaced conditions.
- Current field evidence, including listener reports, of interference to analog reception from IBOC DAB at 1% power is minimal. This may suggest that interference is less noticeable than predicted, however, due to the noiselike nature of IBOC-to-analog interference, which lacks the audible clues of typical analog-to-analog interference, it may be difficult for field listeners to identify an interfering IBOC signal and report their impaired reception.
- Improvements in IBOC DAB receivers and antennas are not currently expected to be a significant remedy for the shortfall in indoor and portable reception. Other techniques, likely transmission-based, will be needed to improve service.
- At 10% IBOC transmission power, most stations would gain covered population, approximately equaling analog indoor and portable and exceeding mobile.
- Unqualified 10% IBOC transmission power is predicted to cause substantial interference to analog reception of a significant number of first- and second-adjacent channel stations.
- Stations on "non-commercial" channels (88.1-91.9 MHz) and "commercial" FM channels (92.1-107.9 MHz) would receive similar amounts of interference to their analog operations from IBOC DAB at 10% power. This is notable since it was expected that commercial channels have more conservative protection standards.
- Initial projected system-wide estimates of the costs of deploying a combination of optimization strategies for indoor digital coverage parity could approach a doubling of transmission investments.
- Input interference to existing analog FM translators, should all stations convert to IBOC DAB, is expected to affect approximately 5% of all translators.

Our findings indicate that several potential strategies should be investigated, and where practical, developed for system-wide improvement in digital radio service:

- Single Frequency Network (SFN) boosters may be approaching Independent Demonstration Of Viability maturity, providing a potentially critical strategy to improve digital indoor coverage, where needed, while controlling analog interference effects. In addition to technical development and testing, an economic analysis is indicated.
- Limited elevation of IBOC transmission power, including separate directional antenna systems for the IBOC transmission and asymmetrical sideband power, should be developed and tested to limit interference to neighboring FM stations.

- Further testing on the impact of elevated IBOC power on consumer receivers, including radio reading service SCA receivers, is needed to develop rational policies for sideband power increases, where appropriate [not all stations will consider it necessary or appropriate].

NPR Labs has worked closely with CPB staff throughout this intensive project and we are gratified by their active engagement, counsel and commitment to this project. The advanced research methods and analysis used in this study are unprecedented. The underlying data developed is voluminous and far reaching. System-wide strategies will require coordination in concert with the project's Communications Plan, as well as focused follow-up research validating and refining promising optimization approaches.

Acknowledgements

NPR expresses our gratitude to the staff of CPB's Digital Media Technologies unit – especially Don Lockett, Senior Director of the unit, Brian Gibbons and Doug Vernier, who individually invested untold hours actively engaged in the progress and rigor of this study from inception to completion.

This study could not have happened with the extraordinary insights and dedication of NPR's Senior Technologist John Kean, the project manager on this effort. Kyle Evans, Jan Andrews, Ellyn Sheffield, Mike Starling, Dianne Brace, Daniel Schwab, and Barbara Freeman also contributed extensively throughout the study.

NPR Labs additionally thanks the staff at ITS in Boulder for customization of the CSPT planning tool for automating the execution of the mapping and population counts. Former NPR staffer Matthew Burrough also contributed to this project. Special thanks also goes to the staff of NPR's Audience Insight and Member Services groups for invaluable work on the signal sensitivity studies, especially Lori Kaplan, Barbara Appleby, Matt Gallivan, and Ben Robins.

Communicate with us, view our complete DRCIA report, and track ongoing digital radio coverage work at: www.nprlabs.org/Research/DRCIA.php.

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