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March 30, 2022

BY ELECTRONIC FILING

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street NE
Washington, DC 20554

Re: NPRM on FM Broadcast Booster Stations, MB Docket No. 20-401, RM-11854; Modernization of Media Initiative, MB Docket No. 17-105

Dear Ms. Dortch:

GeoBroadcast Solutions, LLC ("GeoBroadcast"), by its counsel, is pleased to share the results of a second comprehensive demonstration of the performance of FM geo-targeting technology conducted by Roberson and Associates, LLC ("RAA").[1] Last fall, we presented to the Commission a technical report by RAA showing the high performance of FM radio geo-targeting technology based on a demonstration conducted on KSJO(FM) (San Jose, CA).[2] Following up on comments received from the Audio Division staff about the importance of testing the technology in a different area, RAA tested the FM geo-targeting technology in Jackson, Mississippi, with its characteristically flat terrain which presents greater challenges to all radio transmitters. In February and early March 2022, RAA conducted this test in partnership with WRBJ-FM (Brandon, MS), which services the state capital, Jackson. The attached report on the Jackson test shows the same good results as the San Jose test. Specifically, it demonstrates:

- Geo-targeting technology can be used to deliver hyper-local content (such as news, weather, traffic, and advertisements) to consumers in a seamless experience for the listener.

[1] Roberson and Associates, LLC, is a recognized authority on services in the areas of radio frequency (RF) spectrum management, RF measurement and analysis, strategy development, and technology management. Together, the organization has over 1,400 years of high technology management and technical leadership experience with a strong telecommunications focus.
[2] Ex Parte Letter of Covington & Burling LLP, *Amendment of Section 74.1231 (i) of the Commission's Rules on FM Broadcast Booster Stations*, RM-11854, MB Docket Nos. 17-105, 20-401 (Sept. 17, 2021).

- The technology works completely in tandem with the EAS system, and has no impact on the delivery of EAS alerts.
- The technology performs similarly in the flat terrain of Jackson, MS as it did in the hilly terrain northeast of San Jose.
- The technology can be deployed to create transition areas that take up a negligible portion of a station's road service length.
- The technology can be deployed so that in those minuscule transition areas any impact on a transmission is infrequent, fleeting, and in most cases not noticeable to the listener.

The FCC is considering a proposed rule change that would allow FM broadcasters *on a voluntary basis* to deliver hyper-local programming to listeners within zones for a short, limited period of time (i.e., not more than three minutes per hour). Throughout the proceeding, stakeholders representing many perspectives on the radio industry have explained the potential of geo-targeting technology to advance the goal of localism while also unlocking economic opportunities for broadcasters and advertisers alike. The capability to geo-target content has long been offered to advertisers on all forms of media; *radio is the only media lacking this capability*.[3]

The Jackson demonstration was modeled after the San Jose test. Working with the broadcaster, GeoBroadcast designed and deployed the geo-targeting technology in the WRBJ-FM coverage area. Localized broadcast zones were created while minimizing transition areas (i.e., those miniscule areas, that only exist for a maximum of three minutes per hour, where a listener would enter or leave a zone and exit from or return to the primary signal, respectively). In the Jackson demonstration, the zone transition boundaries were designed to cut across highways and interstate roads, resulting in highly controlled, small transition areas. The balance of these boundaries were designed to fall on unpopulated areas without roads (in this case, the Pearl River and its associated flood plain). This demonstration also explored how altering the distance between an FM booster and the border of a zone reduces the respective transition area. In Jackson, RAA conducted drive tests in real world environments using a commercial grade deployment, with primary focus on traversal of the zone transition area. Detailed data was collected on the FM signal performance (e.g., multipath parameter) and audio-video quality. The zone transition areas were traversed dozens of times at variable speeds and at various times of day.

As suggested by the Audio Division staff, this report builds upon the results of the earlier testing in partnership with KSJO(FM) in San Jose, CA by pressure testing the findings of that research on a different type of terrain and environment. Whereas the KSJO(FM) demonstration tested the performance of FM radio geo-targeting technology in a hilly, rural area, the WRBJ-FM test presented a different setting, analyzing the performance of this technology on a flat terrain in urban and suburban environments. The flat topology of the Jackson demonstration created a near "worst case" environment for the design and deployment of a geo-targeted zone due to the lack of geographic features that can be used to contain signal propagation. In addition, the

[3] The FCC granted TV broadcasters the *voluntary* ability to offer geo-targeted content when it adopted the ATSC 3.0 NEXTGENTV standard in 2017.

WRBJ-FM service area presented difficulties due to the number of roads in the area and location constraints that caused boosters to be placed at varying distances from the road transition areas.

Similar to the San Jose report, this report presents the findings on key factors in the docket: (1) impact on the listener experience in FM transition areas; (2) impact of using FM geo-targeting technology on the signal within each zone; (3) impact on the in-zone transmission resulting from the distance between a booster and the transition area; and (4) the operation of the emergency alert system (EAS) in conjunction with this geo-targeting technology. Below, we provide a brief summary of how RAA's research was conducted and the report's key findings.

1. Research Conditions and Methodology

WRBJ-FM currently operates one main transmitter covering the area from a site southeast of Jackson. Using FCC experimental authority, GeoBroadcast worked with WRBJ-FM to create a geo-targeted zone utilizing a total of six booster sites. Some sites supported more than one transmitter. Most of the booster sites were deployed on fixed infrastructure. However, one booster site utilized a Cell on Wheels (COW) to create the transition area on Highway 25. The COW booster was then moved to a new position, near Highway 80, to determine if reducing the distance between the booster and the road would improve transition area performance. Measurement vehicles were driven over each of the three zone transition areas many times. These vehicles were outfitted with equipment to measure received signal and audio/video quality for the FM signals (the same equipment as was used for the KSJO test).

The conditions for the drive tests in this demonstration system were: (1) entering a zone when geo-targeted broadcast is active; (2) exiting a zone while a geo-targeted broadcast is active; (3) confining a drive route in the known interior of a zone region with and without the zone boosters active. Each of these conditions was designed to assess particular parameters of interest, as described below.

2. Key Findings and Conclusions

Based on their research, RAA concluded that geo-targeted content is unlikely to create any material disturbance in the listener experience and, importantly, frequently will improve signal quality within a zone. We discuss the report's key findings below, which are confirmatory of the results from the San Jose report:

- ***Listeners in FM transition areas experienced no material change.*** As in the KSJO study, the primary metric used to assess the degradation of the listener experience in transition areas was the *multipath* threshold, which measures the reception of multiple versions of a desired signal, which are often caused by environmental processes, such as reflections off nearby buildings or terrain. In the case of geo-targeted transmissions, there are two signals (both desired by the broadcaster) being combined at the receive antenna as a zone transition occurs. The *multipath* threshold for degraded audio quality was set at 20% ─ the same metric used in the San Jose report. In driving over 50 geo-targeting broadcast transitions in Jackson, the observer team did not detect signal instability due to multiple FM capture events.

- Transitions areas occupy a miniscule portion of the roads served by geo-targeted content. RAA found that the average distance of the transition area is 73.9 meters, an insignificant distance in consideration of the total length of 386,100 meters of road that could be traversed by a listener in the broadcast coverage area, which accounts for only 0.11% of the estimated road length within the zone. (To give further context, the Census Bureau reports that Jackson has a total area of 113.2 square miles; 111.0 square miles are land and 2.2 square miles are water.[4]) Moreover, transition areas can frequently be designed to fall over water or in unpopulated areas without roads as was done in Jackson. Finally, the transition areas only appear during the short time intervals each hour when different geo-targeted content is broadcast in the zone and in the main transmitter coverage area.

- Signal was stable inside the transition areas. RAA assessed the signal instability in the transition areas, to determine whether one could pass along a zone transition boundary for some distance, which could create conditions for noteworthy signal instability. After RAA's extensive field tests, they did not detect the occurrence of this type of signal instability.

- ***Technology enhances listener enjoyment inside the zones.*** The research demonstrates that the geo-targeted zone created by the boosters significantly improved coverage and signal quality within a zone, both during the short intervals when ZoneCasting content is being transmitted and during the remainder of the time when identical content is being transmitted, and that the delivered content (e.g., programming and advertisements) was enhanced inside the zones. This is not surprising, given that this has been the purpose of boosters for the past four decades. It bears emphasis that these benefits will be present all the time whereas the geo-targeted content will be available only a few minutes per hour.

- ***Transition areas can be minimized by reducing the distance between a booster antenna and the transition area.*** This relationship is important because, as GeoBroadcast has previously indicated, the size of a transition area is roughly proportional to the distance between the booster antenna and the border of a transition area. Specifically, the closer the antenna is to the border of a zone the smaller the transition area. The Jackson tests definitively confirm that transition area is reduced as the booster antenna is moved nearer to the associated road. With the booster located 300 meters from Highway 80 the measured average transition area size was 206.8 meters. With the booster located 60 meters from Highway 80 the measured average transition area size was reduced to only 14.6 meters.

- ***Operation of the EAS geo-targeting override.*** The research confirms the results from the San Jose test: geo-targeted broadcasting works in tandem with the EAS system and does not affect its performance. RAA tested this issue through simultaneous reception of

[4] "Geographic Identifiers: 2010 Census Summary File 1 (G001): Jackson city, Mississippi," American Factfinder, U.S. Census Bureau.

identical EAS tones at two locations, using separate measurement systems in two separate vehicles.

* * *

RAA's research in partnership with WRBJ-FM shows that geo-targeting technology can be deployed by those radio broadcasters who choose to do so to deliver localized content to the audience without negatively impacting the listener experience, across a variety of environments and terrains. Moreover, it demonstrates that stations have multiple variables at their disposal and every incentive to use them, should they choose to adopt FM radio geo-targeting technology, to minimize any disruption to the listener experience, such as controlling the placement of boosters and transition areas. Finally, it shows that FM radio geo-targeting technology can be deployed without affecting the performance of the EAS system.

We believe these reports establish a strong basis for the efficacy of FM radio geo-targeting technology. We hope the Commission sees how this technology can be used to enhance localism and serve the public interest, and ask that it consider the record on this matter complete and move forward promptly with a final rule.

Sincerely,

/s/
Gerard J. Waldron
Madeline Salinas
Counsel to GeoBroadcast Solutions

Attachment

WRBJ Demonstration System

Geo-Targeted FM Broadcast Technical Report

This report delivers a summary of key technical measurements and associated analysis information on the performance of the geo-targeted broadcast demonstration system deployed in collaboration with the WRBJ commercial FM radio station in Jackson, MS. Additional technical information necessary to understand the context for this demonstration system's performance is also provided.

Prepared for: GeoBroadcast Solutions

Date: 30 March 2022

Version: 1.0

Roberson and Associates, LLC

Contributors: M. Birchler, J. Grosspietsch & D. Roberson

EXECUTIVE SUMMARY

Demonstration Overview

Many media organizations such as online content providers, cable operators, and television broadcasters have the ability to use advanced technology to deliver geo-targeted content to their audiences. However, the radio broadcast industry currently lacks this ability. This report analyzes the performance of a technology that would enable radio broadcasters to geo-target content. The technology creates local zones within an FM broadcast coverage area that enable unique, targeted content for listeners in those local, geo-targeted zones during short periods (e.g., 3 minutes per hour) and are designed to work seamlessly with the listener experience. The zones are created using carefully located and synchronized booster transmitters and appropriately designed antennas to overlay a stronger, geographically localized signal in the targeted region.

The basis for this report is a geo-targeted broadcast demonstration system that has been deployed in the WRBJ (Jackson, MS) broadcaster coverage area using technology developed by GeoBroadcast Solutions, LLC ("GeoBroadcast Solutions"). WRBJ is a Class A station that transmits analog FM signals only (i.e., HD Radio is not used).

The demo system was designed (as any broadcaster would have the incentive and ability to do so), to minimize the size of the transition region between zones (i.e., the small geographical area in which the main transmitter and zone transmitter have similar received field strength). In addition, the demo system was designed to significantly improve the coverage and therefore the consumer listening experience within the geo-targeted zone. The demo system is comparable to a system that would be used in a commercial-level deployment.

This demonstration and associated measurements conclusively show that a geo-targeted zone can be created in suburban and urban environments on flat terrain that meets identified success criteria. These deployment conditions differ significantly from those of the recent KSJO demonstration system (see [7]), which was in a hilly, rural area. Between the WRJB and KSJO demonstrations, the major geographic and building types identified as key to a thorough demonstration of this technology have been covered.

Results Summary

Overview of Demonstration. To conduct this demonstration, a local broadcast zone was created that was designed to minimize transition areas. Transition areas are geographic sub-regions occurring at the boundary of a zone, where the power of the localized zone signal is similar to the power of the Main FM broadcast signal. Broadcasters, like every other FCC licensee, have a strong incentive to manage and maximize signal stability, and in this case that can be accomplished by designing the boosters so that transition areas are small and located in mostly unpopulated areas. Brief transitions may occur for listeners in automobiles entering and leaving the zone during the time-limited local broadcast events (at most 3 minutes/hour). In this demonstration, as for all system designs of this kind, these transition areas were designed and programmed to be infrequent, transitory, unobjectionable and in many cases unobservable.

This demonstration system allowed drive tests to be conducted in real world environments using a commercial grade deployment, with a primary focus on traversal of the zone transition regions. Detailed data was collected on the FM signal performance (e.g., multipath parameter, as discussed herein). Three zone transition regions were traversed 50 times at variable speeds and at various times of day for transition length measurements.

Overview of Test Results. This report shares the data collected from this demonstration system, provides technical and, as appropriate, experiential assessments, discusses the technical implications for geo-targeted broadcast viability, and addresses various questions raised in the FCC's FM Booster NPRM proceeding, in private meetings with the major FM Network CTOs and in *ex parte* meetings with FCC staff. Key conclusions include:

- General Transition (see Section 4.1 for detailed results)
    - Our measurement results using the Nomad measurement device's *multipath* parameter indicate an average zone transition distance across all 50 zone transitions for the three transition regions of 73.9 meters. The *multipath* parameter is the indicator chosen to measure disruption to a received radio transmission, as discussed further in this report (as well as in our past research in partnership with KSJO(FM)),
    - For reference, a vehicle traveling at 60 mph will traverse the average transition region of 73.9 meters in 2.8 seconds.
    - This average transition distance is insignificant when compared to the total length of roads within the zone, i.e., 386,100 meters, that could be traversed by a listener, and accounts for only 0.11% of the estimated road length within the zone (see Section 4.1.4 for calculation details).
    - The area over which this FM zone transition occurs is highly stable, as is the general received signal behavior.
    - The zone transition boundaries were designed to cut across highways and interstate roads, resulting in highly controlled, small transition regions. The balance of these transition boundaries were designed to fall on unpopulated areas without roads (in this case the Pearl River and its associated flood plain).
    - In driving over 50 geo-targeting broadcast transitions, the observer team did not detect signal instability due to multiple FM capture effect events.
- Commercial Deployment and Coverage (see Section 4.2 for detailed results)
    - In both key design areas (i.e., minimized transition region and improved zone coverage) the demo system is a credible instance of an actual commercial deployment.
    - Real commercial advertisements were included in the broadcast content.
    - The general zone coverage was assessed, with results indicating that the geo-targeting zone created by the boosters significantly improves WJRB coverage within the zone.
- Emergency Alert System (EAS) (see Section 4.3 for detailed results)
    - Operation of the WRBJ EAS geo-targeting override was tested simultaneously in two locations to ensure that the EAS broadcast controls function properly.
    - The simultaneous reception of identical EAS tones at these two locations confirms that geo-targeted broadcasting will not affect performance of the EAS system.

Highway 80 Deployment Experiment

A transition region size experiment was conducted by measuring performance with and without a Cell on Wheels (COW) positioned near to Highway 80. This experiment assessed the enhancement of the Highway 80 transition region performance through reduction in the distance between the booster antenna and the highway.

This relationship is important because, as GeoBroadcast Solutions has previously communicated, the size of a zone transition region is roughly proportional to the distance between the booster antenna and the region. Specifically, the closer the antenna is to the transition region the shorter the transition region.

The results of this experiment definitively confirm the GeoBroadcast Solutions claim that transition region size is reduced as the booster antenna is moved nearer to the associated road. With the booster located 300 meters from Highway 80 the measured average transition region size was 206.8 meters. With the booster located 60 meters from Highway 80 the measured average transition region size was reduced to only 14.6 meters.

Conclusions

The system in Jackson was the second recent demonstration for which Roberson and Associates, LLC conducted measurements on geo-targeting technology using FM boosters. The first was conducted in the San Jose area and that report (see [7]) was filed with the FCC on September 17, 2021, which produced results showing the efficacy of this technology. The San Jose report, however, was based on a demonstration conducted in hilly terrain, which can provide a level of natural shielding. Therefore, the WRBJ demonstration was intended to test the performance of geo-targeting technology using FM boosters in a more challenging physical environment.

Therefore, this demonstration was conducted in Jackson, MS, with its characteristic flat topology that is a near "worst case" environment for the design and deployment of a geo-targeted zone. This is due to the lack of geographic features that can be used to block signal propagation. In addition, due to the number of roads and practical site location constraints, the boosters used to create the geo-targeted zone were located at various distances from the road transition regions. As noted above, the further the distance between the boosters and road, the larger is the resulting transition region.

Thus, the resulting average transition length of 73.9 meters provides high confidence that this geo-targeting technology will provide minimal impact on the user listening experience across all topology types. Moreover, as emphasized above, the environment for this demonstration was a near "worst case" environment. Thus, the average transition length of 73.9 meters, when compared with an average transition length of 50.2 meters in our San Jose demonstration, shows that even the most difficult terrain is unlikely to drastically impact the performance of geo-targeting technology using FM boosters.

We also note that even in flat terrain the transition region size can be significantly reduced by placement of the booster antenna nearer to a road. Thus, a broadcaster can achieve a desired level of transition zone performance through proper system design. In the Jackson system case, our experimental results show that the transition region size was dramatically reduced from 206.8 meters to 14.6 meters by placement of the booster nearer to Highway 80. If desired, the transition region for the I-20 likely could have been reduced through placement of a booster (or boosters) closer to this complex roadway intersection.

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1 BACKGROUND

1.1 Demonstration System

1.1.1 Purpose and Goals

The WRBJ demonstration system is intended to show how geo-targeted broadcasting can deliver significant value to broadcasters, advertisers, emergency alert systems and distinct communities with more relevant programming and information. For example, a zone can be designed to serve a specific geographically localized community with relevant traffic and weather information, or with community relevant language and/or culturally specific content. In addition to simulations of the ZoneCasting™ technology, three broadcasters have previously deployed geo-targeted demonstration systems[1], with WRBJ being the fourth and likely most challenging demonstration to date. The region in which the testing took place is shown in the topological plot of Figure 1. Note that the Jackson area is very flat, as indicated by this topographical map.

[1] (1) Lazer Spots, LLC, Bustos Media of Utah License, LLC, KDUT(FM) and (2) Alpha Media Licensee LLC Partnership, WIIL Channel: 236B 95.1 MHz Union Grove, WI, and (3) KSJO, San Jose, CA. [7]

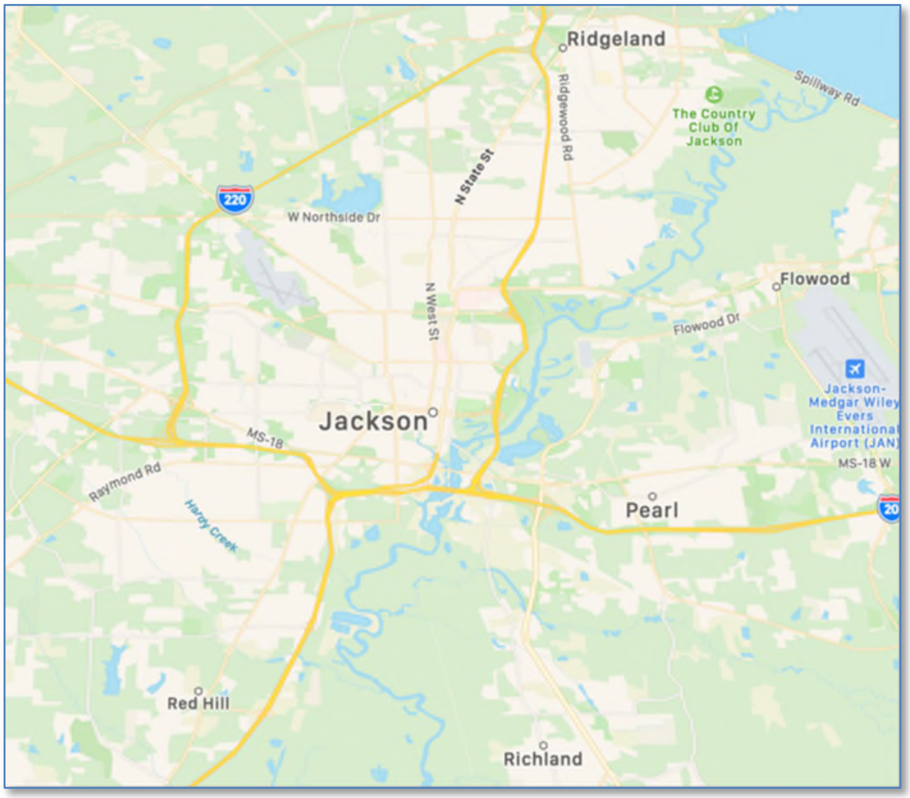

Figure 1. Jackson MS Area Geographic Features

WRBJ is a licensed Class A FM broadcaster in Jackson, Mississippi and currently operates one transmitter.[2] WRBJ transmits analog FM signals only (i.e., HD Radio is not used). The Main transmitter covers the Jackson region from a site south-east of Jackson. Figure 2 shows the WRBJ coverage area prior to installation of the geo-targeting boosters. The city of Jackson is on the western edge of the coverage contour.

[2] WRBJ is a fully spaced Class A station (73.207) on 97.7MHz, it operates with 6 kW at a 100 meter antenna height which is the maximum class A facility, License # BLH-20060629ACK.

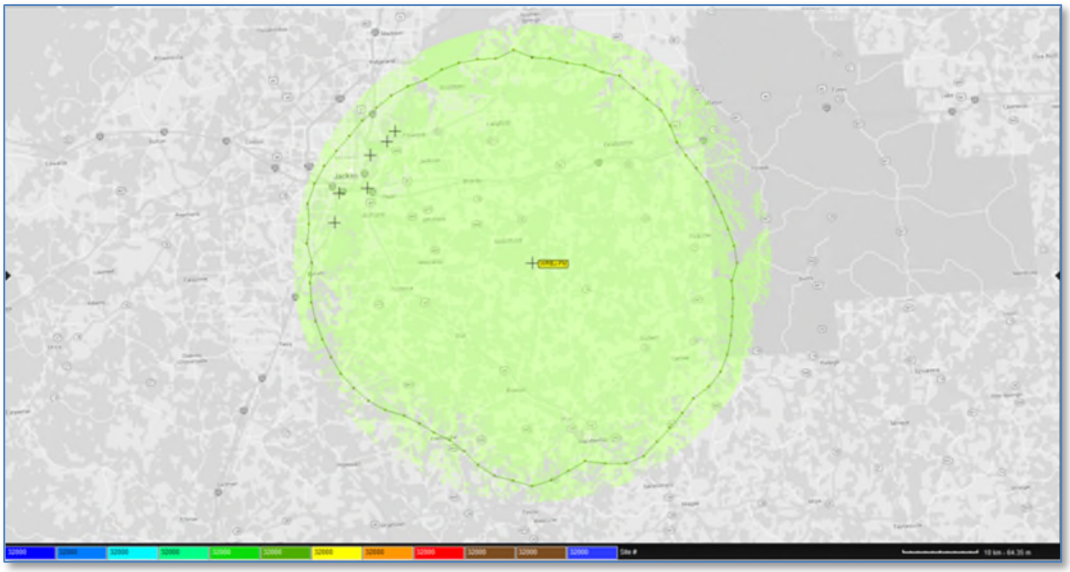

Figure 2. WRBJ Main Coverage Area[3]

A zone has been created by deploying nine low power boosters These additional boosters operate under a temporary Experiment Authorization from the FCC. The transition zone is designed to fall on the Pearl River which runs from the northeast to the southwest on the East side of Jackson.

Some commenters in the FCC's FM Booster NPRM have raised technical questions about the geo-targeted broadcasting proposal (see Section 1.2). The following areas have been identified as being addressable by this demonstration system with a particular focus on the performance of the system in the transition zones:

- General Transition
- Commercial Deployment and Coverage
- Emergency Alert System (EAS).

The purpose of this demonstration is to generate and assess the technical data necessary to address many of these concerns. The specific goals of the demonstration measurements are to:

- Collect FM Radio measurements and received audio/video samples while entering or exiting zones during geo-targeted broadcast events
- Collect FM Radio measurements and record received audio/video samples within a zone
- Allow interested parties to listen to geo-targeted broadcast content and experience transitions between Main and zone programming in a real-world deployment based on commercial equipment
- Support mobile and stationary data collection

[3] The line (see the green line of connected dots) is the 60 dBu FCC contour. The green shaded area shows the coverage calculated using 39 dBu for monophonic FM.

- Assess the relationship between booster antenna location relative to a road and transition region size.

1.1.2 Demo Approach

With the FCC's Experimental Authority to originate FM booster content, geo-targeted broadcasting was installed using boosters to create the zone coverage area. Figure 3 shows a zoomed in region of the main coverage area prior to the addition of the boosters. This particular area was selected because it contains the three Transition Regions discussed in Section 2.3.

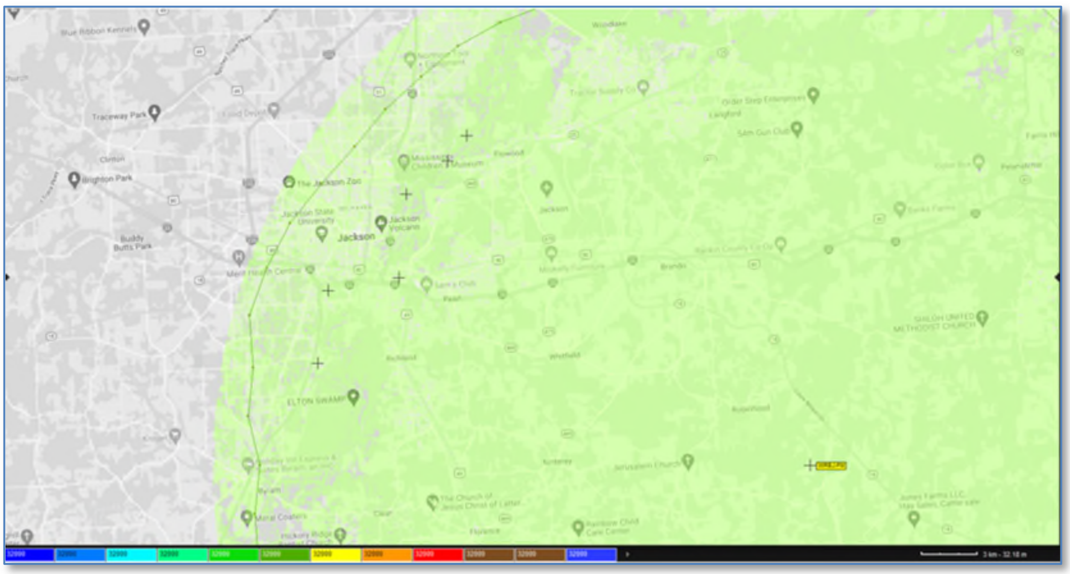

Figure 3. WRBJ Main Coverage Detail

Note that two booster deployments were utilized. The first deployment was designed to create the geo-targeted zone (see Section 1.1.2.1). The second deployment moved the Cell on Wheels (COW) from its position near Highway 25 to a new position near to Highway 80 (see Section 1.1.2.2). This move was implemented to assess enhancement of the Highway 80 transition region performance through reduction in distance between the booster antenna and the highway.

1.1.2.1 Highway 25 Deployment

Table 1 provides details on the booster deployments used to create the geo-targeted zone for Highway 25 coverage. Note that the "Derrick", "Jackson S." and "Route 25" sites use dual antennas pointing in the two directions indicated in the "Azimuth" column.

Site Name	Structure Type	Lat.	Lon.	ERP (w)	AGL (m)	Azimuth (°)	Antenna
Derrick	Tower	32.27663	-90.16511	240/240	24	315/135	Single log/single log pattern
Jackson S.	Tower	32.27389	-90.20500	200	45	260/210	Single log/dual log composite pattern
Savannah	Tower	32.23917	-90.21472	100	45	215	Dual Log pattern
RiverSide	Tower	32.32289	-90.15744	30	45	300	Dual Log pattern
Route 25	COW	32.33213	-90.13548	65/65	21.5	310/130	Single log/single log pattern
Jackson N.	Monopole	32.34367	-90.12347	55	39.5	350	Dual Log pattern

Table 1. Highway 25 Booster Site Deployment Details

Figure 4 shows a geographic overview of the demo system coverage areas. Note that this system consists of a Main coverage zone (green-shaded) provided by the broadcaster and the geo-targeted broadcast zone (purple-shaded) provided by the boosters.

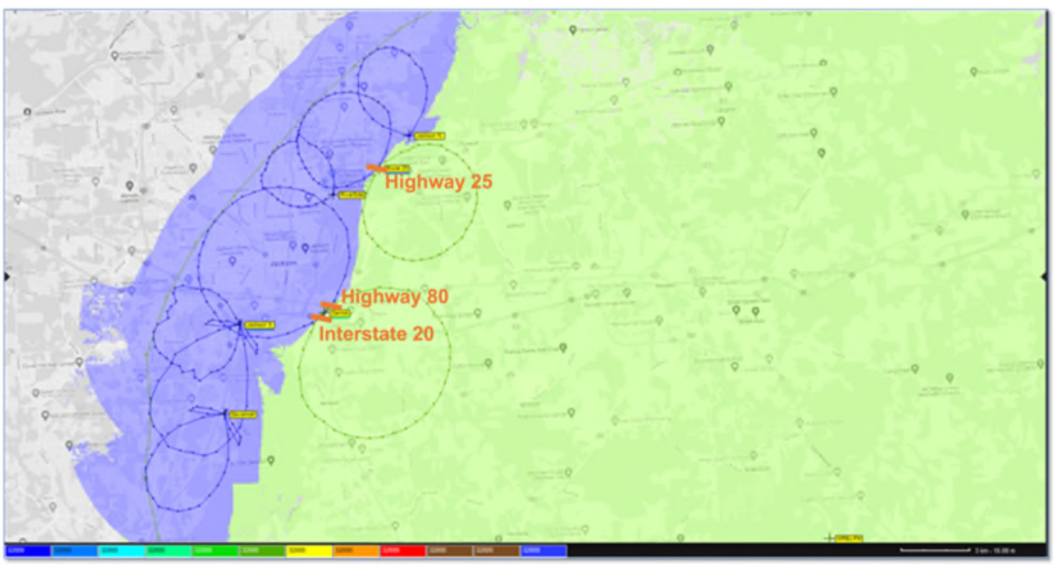

Figure 4. WRBJ Demonstration (Best Server) System Overview[4]

Figure 5 shows the 60 dBu contours of the Main and booster sites. Note that all booster contours are within the Main contour.

[4] The contour line is the 60 dBu FCC contour. The area coverage was calculated using 39 dBu for monophonic FM.

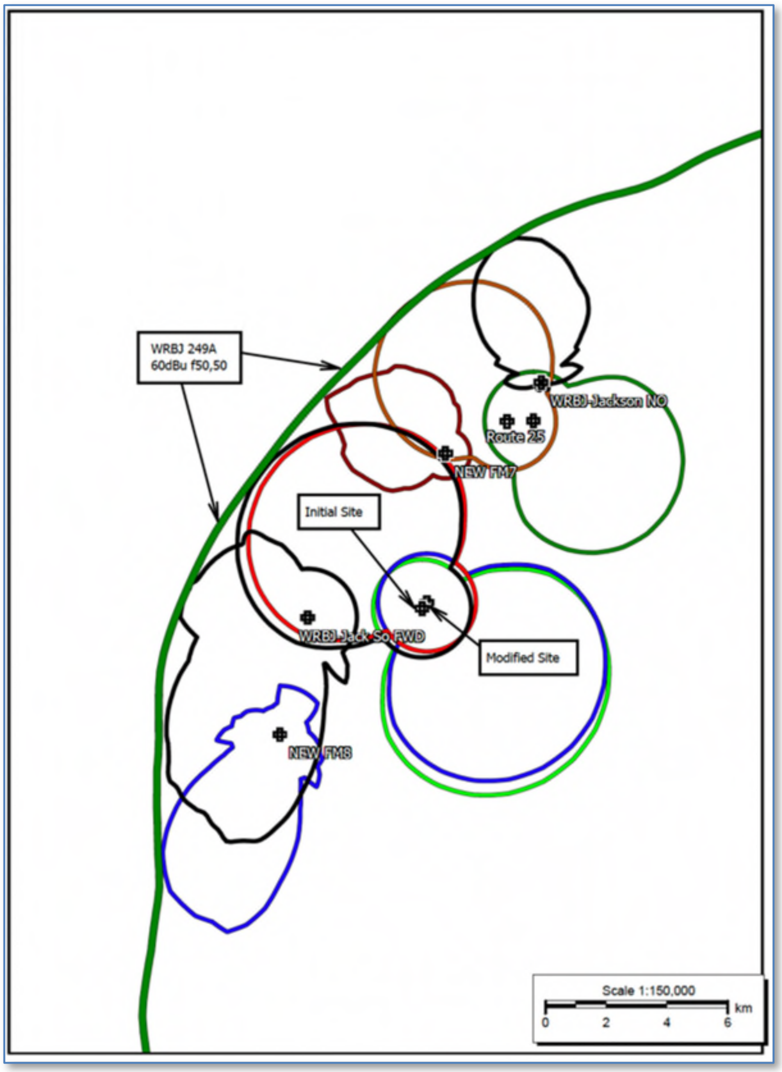

Figure 5. Main and Booster 60 dBu Contours

The zone transition measurements and resulting statistics for this deployment are contained in Section 4.

1.1.2.2 Highway 80 Deployment

Table 2 provides details on the booster deployments used to create the geo-targeted zone for Highway 80 coverage (the new COW location is shown as the light blue shaded row).

Site Name	Structure Type	Lat.	Lon.	ERP(w)	AGL(m)	Azimuth(°)	Antenna
Derrick	Tower	32.27663	-90.16511	240/240	24	315/135	Single log/single log pattern
Jackson S.	Tower	32.27389	-90.20500	200	45	260/210	Single log/dual log composite pattern
Savannah	Tower	32.23917	-90.21472	100	45	215	Dual Log pattern
RiverSide	Tower	32.32289	-90.15744	30	45	300	Dual Log pattern
Jackson N.	Monopole	32.34367	-90.12347	55	39.5	350	Dual Log pattern
Hwy. 80	COW	32.27839	-90.16344	200	20	315/135	Single log/single log pattern

Table 2. Highway 80 Booster Site Deployment Details

The zone transition measurements and resulting statistics for this deployment are contained in Section 4.

1.1.2.3 Highway 80 Performance Experiment

The moveable Cell on Wheels (COW) enabled experimentation on the relationship between booster antenna location relative to a road and transition region size. Specifically, the transition region size on Highway 80 was measured using boosters at two distances from the highway.

This relationship is important because, as GeoBroadcast Solutions has previously communicated, the size of a zone transition region is proportional to the distance between the booster antenna and the region. Specifically, the closer the antenna to the transition region the shorter the transition region.

Therefore, after completion of the Highway 25 measurements, the COW booster antenna was placed at a location approximately 60 meters from Highway 80 in order to assess this claim. Figure 6 shows the two experimental booster antenna locations used for this assessment. The first booster location is shown in light blue and is the Tower location (see the Derrick row in Table 1). The second booster location is shown in green and is the COW location. Distances from these two locations have been estimated, resulting in approximately 300 meters for the Tower and 60 meters for the COW.

Transition region performance for the COW booster is contained in Section 4.1.2 and for the Tower booster in Appendix D.

Figure 6. Two Experimental Booster Antenna Locations for Highway 80

1.1.2.4 Data Collection Overview

A measurement vehicle was outfitted with the equipment described below to measure received signal quality for the FM Radio signals. The vehicle was driven along Interstate 20 and Highways 25 and 80 to collect transition region data. In addition, we drove within the zone along Highway 55 to collect measurements. The vehicle also was driven along Highway 55 near the contour edge north and south of Jackson.

The Octave Nomad system was used to collect MP3 audio and detailed measurements of the received FM signals for this measurement campaign, and its software was configured to collect detailed information about the received FM signal quality (see Section 2).

Drive route types were selected to enable the three test conditions shown in Figure 7, those being:

1. Enter a zone when geo-targeted broadcast is active. The parameters of interest are the duration of the transition between the Main signal and the zone signal while driving, and the perceived and measured audio quality before, during, and after passing through the transition zone.
2. Exit a zone while a geo-targeted broadcast is active. Here the parameters of interest are the duration of the transition between the zone signal and the Main signal while driving, and the perceived and measured audio quality before, during, and after passing through the transition zone.

3. Confined drive route in the known interior of the zone region. Here the parameters of interest are the audio quality during the turn-On and turn-Off of the geo-targeted broadcast transmission.

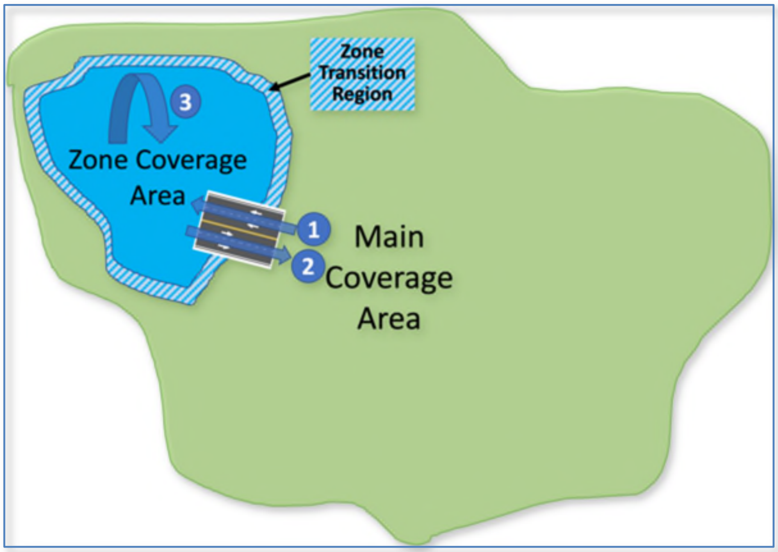

Figure 7. Simplified Diagram of Drive Tests

1.2 Success Criteria

Coverage of key "success criteria" items, as identified by key stakeholders and commenters, has been a primary driver for demo design and measurements.

1.2.1 Background on Contributors

As explained in detail in our San Jose Report [7], we derived these "success criteria" from filings in the FCC FM Booster proceeding and a meeting with the Chief Technology Officers of the largest FM radio station networks.[5] The purpose was to ensure that the field demonstration data for geo-targeted broadcasts sufficiently covered the key requirements raised by the NPRM and interview process.

The following section contains the selected "success criteria" technical items that are addressable using this demo system along with our current assessment of coverage.

1.2.2 Success Criteria

1.2.2.1 General Transition

These criteria deal with the general case of transition between broadcast coverage areas.

[5] See references [2] through [6] and Appendix B.

SC ID#	Criterion Description	Assessment Rationale
1	Flat	Zone transition areas occur on roads over flat terrain.
6	Suburban	Transition regions include variable levels of building density, some of which are similar to a suburban environment.
7	Urban	Transition regions are in urban environments.
10	Multiple transition areas between Zone and Main; and between Boosters within a Zone. At least four transitions at a demo location and at least three boosters.	Sufficient number of boosters and transitions to meet criterion.
25	"Xperi believes interference is a genuine concern with ZoneCasting, especially at zone boundaries. For analog-only ZoneCasting, the transition region will be characterized by potentially frequent switches between different audio programs, as determined by the FM receiver's capture effect. As vehicles travel in and out of an audio zone, there is a probability that the audio will transition between the different analog content.	Hypothesis tested via multiple data collection trips through the Zone transition areas.
31	Commenters list myriad concerns and circumstances that remain untested under real world conditions including field tests of ZoneCasting's impact on signal quality in areas with varying terrain, when a booster is located at different locations within a market and when a listener travelling in an automobile moves from a booster zone back to the primary station zone In particular, the FCC must gather significantly more data on ZoneCasting in a mobile environment before moving forward.	Mobile environment testing occurred in a real-world geo-targeted broadcast deployment.
42	(1) Determine the size of the main/booster transition region upon entering a zone with ZoneCasting enabled by measuring objective and subjective audio quality (i) before entering, (ii) within, and (iii) after leaving the transition region. Pay particular attention to the audio output of the receiver – noting whether it is analog or digital, main or booster – and the number of times the audio changes from one program to another. Also note the quality of any analog/digital blends.	Multiple Zone transition area data collection across numerous parameters
43	(2) Repeat test (1), but while moving in the opposite direction (that is, starting from within a zone with ZoneCasting enabled, moving through the transition region, and ending outside the zone in the main coverage area).	Multiple Zone transition area data collection across numerous parameters

Figure 8. Success Criteria: General Transition

1.2.2.2 Commercial Deployment and Coverage

We are interpreting ID#s 44 and 45 to include data collection within the zone as well as in the transition region.

SC ID#	Criterion Description	Assessment Rationale
11	Demo scenario must be a credible instance of an actual commercial deployment	The demo system was designed to deliver a minimized Zone transition area and to enhance overall coverage within the Zone.
41	Nor will the recently authorized experimental authority in San Jose, California, for ZoneCasting™ boosters in a terrain-shielded mountain pass, prove useful in answering the majority of outstanding technical questions raised by the Joint Commenters and others in this proceeding.	Data collected in Jackson pertains to flat terrain that is distinct from the specifics of San Jose terrain.
44	(3) Repeat test (1), but with the vehicle moving within the ZoneCasting zone while ZoneCasting is enabled and disabled.	Drive tests within the Zone conducted.
45	(4) Repeat test (3) within a transition region of a ZoneCasting zone that is confined to a low-population area.	Drive tests within the Zone conducted.

Figure 9. Success Criteria: Commercial Deployment and Coverage

1.2.2.3 Emergency Alert System (EAS)

The Emergency Alert System (EAS) is described by the Federal Communications Commission (FCC) as follows.[6]

> "The Emergency Alert System (EAS) is a national public warning system commonly used by state and local authorities to deliver important emergency information, such as weather and AMBER alerts, to affected communities. EAS participants – radio and television broadcasters, cable systems, satellite radio and television providers, and wireline video providers – deliver local alerts on a voluntary basis, but they are required to provide the capability for the President to address the public during a national emergency.
>
> The Federal Emergency Management Agency (FEMA), the FCC, and the National Oceanic and Atmospheric Administration's National Weather Service (NWS) work collaboratively to maintain the EAS and Wireless Emergency Alerts, which are the two main components of the national public warning system and enable authorities at all levels of government to send urgent emergency information to the public.
>
> FEMA is responsible for any national-level activation, tests, and exercises of the EAS.
>
> The FCC's role includes establishing technical standards for EAS participants, procedures for EAS participants to follow in the event the system is activated, and testing protocols for EAS participants.
>
> Alerts are created by authorized federal, state, and local authorities. The FCC does not create or transmit EAS alerts.
>
> The majority of EAS alerts originate from the National Weather Service in response to severe weather events, but an increasing number of state, local, territorial, and tribal authorities also

[6] See https://www.fcc.gov/emergency-alert-system

send alerts. In addition, the NOAA Weather Radio All Hazards network, the only federally sponsored radio transmission of warning information to the public, is part of the EAS."

As the EAS is crucial to public safety it is important that the deployment of a geo-targeted broadcast system has no effect on the reliability or accuracy of EAS alerts.

SC ID#	Criterion Description	Assessment Rationale
32	FEMA is concerned that listeners who are not rapidly traveling through an interference zone will miss a significant portion, if not all, of an EAS message. There is no information on how to prevent disruption to an EAS message if a booster originates programming for three minutes intersects with a two minute EAS message. FEMA is also concerned about the impact of implementing ZoneCasting at designated Local Primary Entry point and other stations that are monitored for EAS messages.	EAS tests conducted.

Figure 10. Success Criteria: EAS

2 DATA COLLECTION

2.1 Equipment

The primary equipment set used to record the quality and characteristics of the zone and Main broadcast signals is listed below.

Name/Model	Description
Octave Nomad with 2 Inovonics Sofia 568 receivers 4-way splitter, BU353-S4 GPS receiver, and Signal Hound spectrum analyzer	FM HD Radio receiver and analyzer. Saves location tagged and time stamped measurements, power spectrum measurements, and audio MP3 files. Note that the Sofia receiver is designed to monitor received raw FM signal characteristics. Commercial receivers are designed to deliver best possible audio quality.
GoPro Hero 8 Cameras with Media Mod	Cameras primarily used to capture dashboard radio video and audio
Vehicle in-dash entertainment system	FM / HD Listening radio receiver
250 Watt True Sine Inverter	12V to 120VAC Inverter for Nomad
100 Watt Inverter	12V to 120VAC Inverter for Nomad laptop computer

Table 3. Vehicle Test and Measurement System Equipment List

2.2 Measurements and Parameters

An Octave Communications Nomad measurement unit was used to collect MP3 audio and detailed measurements of the received FM signals. The Nomad unit was comprised of two Inovonics Sofia

568 FM HD monitor receivers, a Signal Hound spectrum Analyzer, a GlobalSat BU353-S4 GPS receiver, and a laptop running Nomad software.

The first Sofia 568 was set up to receive FM and record audio.

The Nomad software runs on a laptop and connects to the receivers, spectrum analyzer, and GPS receiver over a USB-Ethernet link. Two inverters were used to power the Nomad measurement system. The first inverter powered the Nomad equipment, and the second inverter powered the laptop.

The 568 monitor receivers save data to csv files that are analyzed after completion of testing. During drive tests audio samples and measurements are saved and the location is recorded. The measurements are time-stamped and location-stamped (latitude and longitude). The temporal duration and length in meters of transition zones and signal mute events is characterized by post-processing the measurements.

The Nomad data was collected in a single set of campaign files that included multiple passes through the transition zones. The data for each transition zone pass was extracted during post-processing.

2.2.1 FM Signal

FM major signal parameters are recorded by the Nomad. FM measurements include the following items.

Measurement Name	Measurement Description
Multipath (%)	FM analog signal multipath causes frequency dependent fading across the FM channel and the relation between the two signals is measured
RSSI (dBuV)	Reception level at the receiver input
SNR (dB)	Signal-to-Noise Ratio

Table 4. FM Measurements

2.2.2 Audio/Video Recordings

During a subset of the drives, we recorded the audio and entertainment system display screens. GoPro cameras were used to record both audio and video from the dashboard radio. The recordings were made in Linear mode with a resolution of 1080P and either 24 or 30 frames per second depending on the entertainment system screen refresh rate. The Zoom was set to maximum (2X). The GoPro internal GPS receiver was enabled, and the time was set to the local time.

2.2.3 Practical Considerations

Recordings have been made for each of the different selected drive routes. In addition to driving through transition zones, in-zone listening demonstrations and audio/video recordings of FM signals have been made. The purpose of these recordings is to observe the receiver audio/video transition behavior from the Main and the zone signal.

2.3 Transition Area Drive Routes

Transition region length measurements were conducted for three transition areas as shown in Figure 11. Each of these three areas has a major road that intersects the transition region.

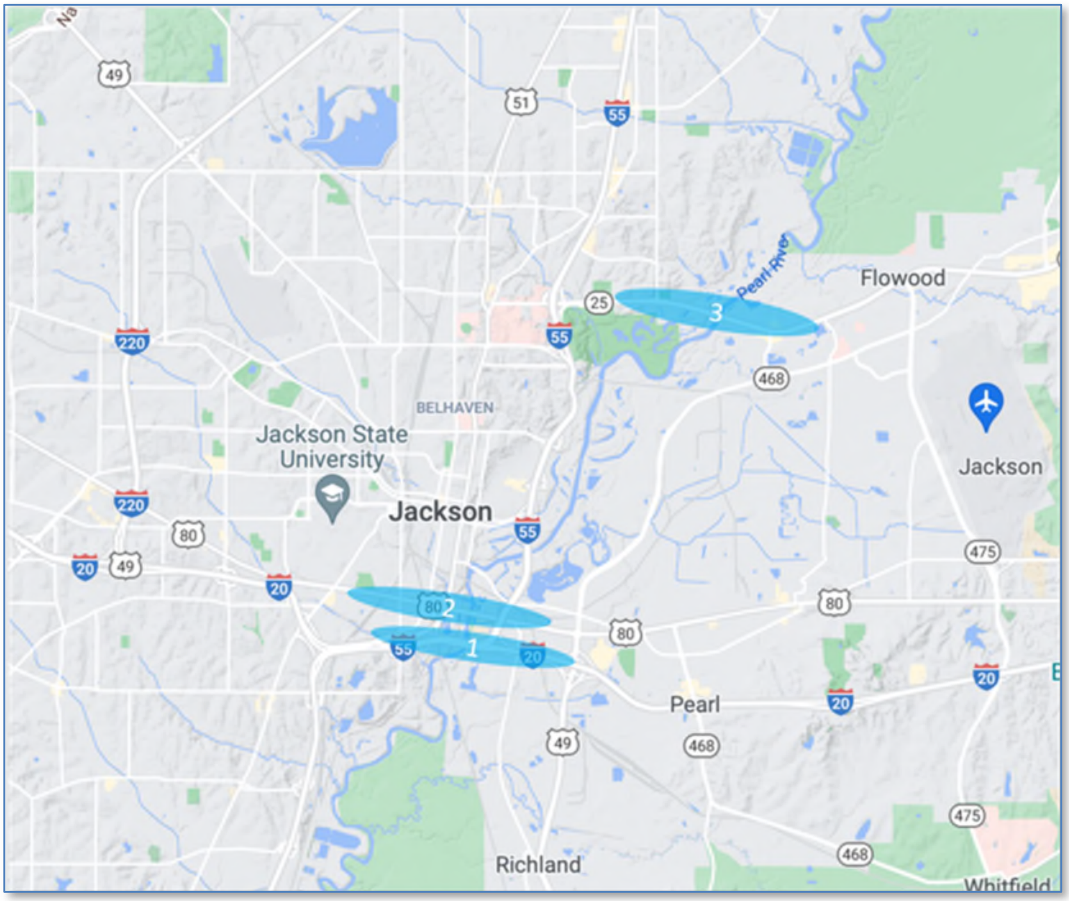

Figure 11. Three Transition Areas

As shown in Figure 11, Transition Area 1 encompasses Interstate 20 along with associated entrance and exit ramps, Transition Area 2 covers Highway 80 and Transition Area 3 covers Highway 25.

2.3.1 Area 1: Interstate 20 and Area 2: Highway 80

Interstate 20 is a major highway running east and west on the south side of Jackson. There are multiple entrance and exit ramps along with ramps to merge onto either Interstate 55 north or south. Passes through the I-20 transition regions were combined with passes through the Highway 80 transition region. Figure 12 shows the combined drive route for I-20 and Hwy. 80 for the majority of the measurement runs.

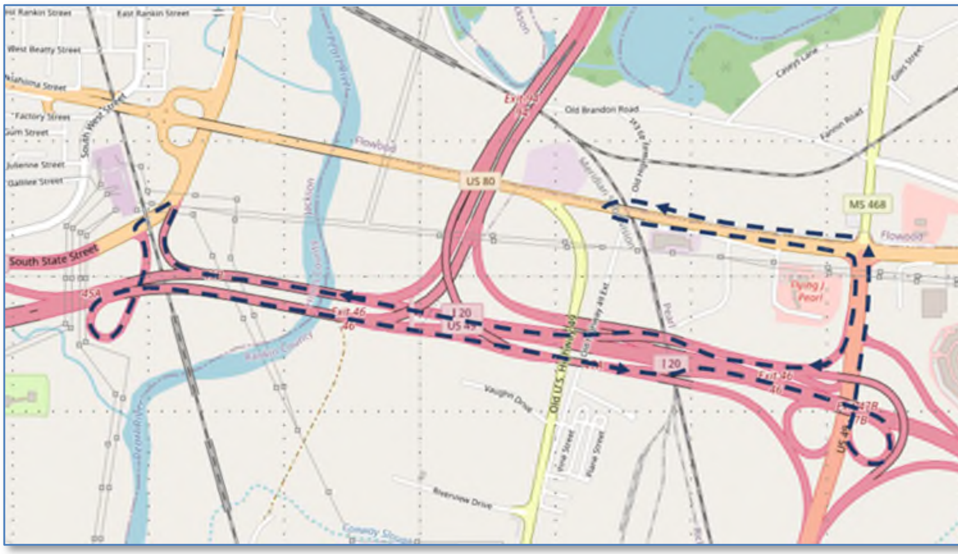

Figure 12. Drive Route for Transition Areas 1 and 2

The transition region of Highway 80 was also traversed multiple times with the Enhanced Highway 80 booster location discussed in Section 1.1.2.2.

2.3.2 Area 3: Highway 25

Highway 25 is a four-lane divided road running east-west between Flowood and Jackson. There are multiple opportunities to make U-turns east or west of the transition region. The transition region is about 480 meters west of the Pearl River. Figure 13 shows the route used.

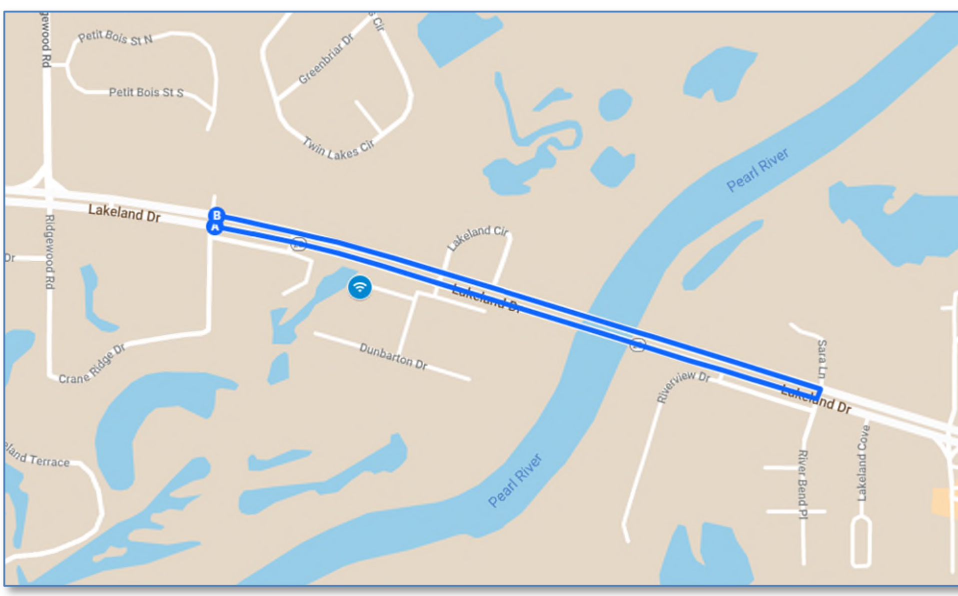

Figure 13. Drive Route for Transition Area 3

2.4 Interior Zone

The drive route in the interior zone area was along Interstate 55 as shown below.

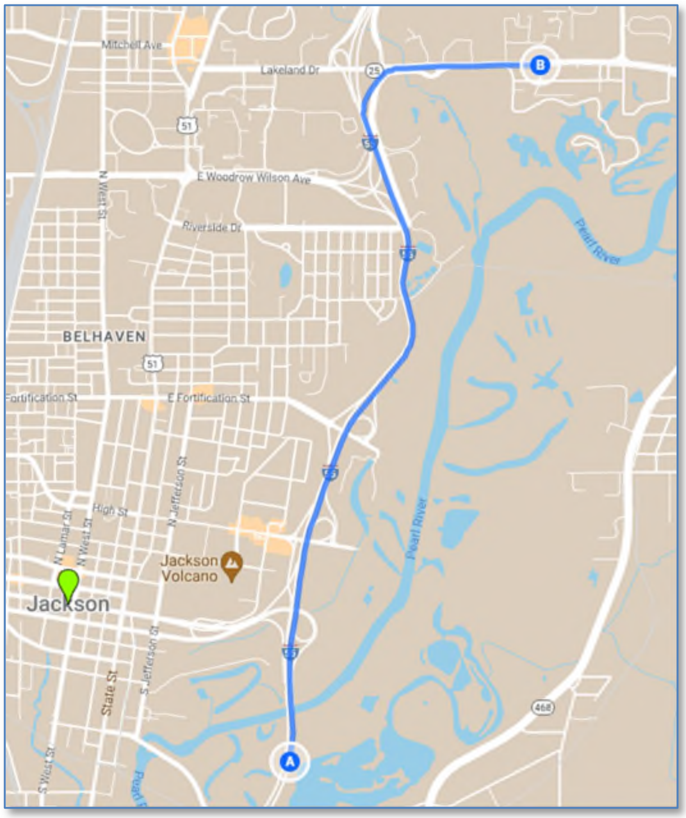

Figure 14. WRJB Interior Zone Area Route

Measurement results for this route are included in Section 4.2.2.

3 KEY PERFORMANCE EVALUATION ISSUES

Two issues central to correct assessment and interpretation of results are discussed in detail below.

3.1 Transition Region Size

The purpose of the transition analysis is to determine the size of the transition region and to assess the signal stability where reception switches between the Main broadcast signal and the geo-targeted signal. The RF propagation software provides numerous measurement parameters which are candidates upon which to base this measurement process.

3.1.1 Multipath Parameter for FM Transition Region Size Assessment

We have assessed the native RF parameters used by the Octave Nomad device for their utility in measuring geo-targeted broadcast transition events. Although a few parameters have utility in this domain, the *multipath*[7] measurement is clearly the most reliable and useful.

The reason for this conclusion is that the *multipath* parameter is designed to measure the reception of multiple versions of a desired signal. In the typical multipath case these multiple received signals are caused by environmental processes, such as reflections off nearby buildings or terrain. These time-delayed, amplitude altered and phase shifted reflected signals combine with the Main signal at the receive antenna to generate a composite received signal. The user perceived audio quality can be degraded by this multipath process[8] if these reflected signals comprise a sufficiently great percentage of the total received signal power.

In the case of geo-targeted transmissions there are two signals (importantly both desired by the broadcaster and managed by the broadcaster, see Section 3.2) being combined at the receive antenna as a zone transition occurs. Our analysis of the *multipath* parameter indicates that it captures this process, delivering distinct and relevant data. Details concerning interpretation and utilization follow.

3.1.1.1 Relative Distance from Transition Region Mid-Point

To assess the size of the zone transition, *multipath* plots have been generated with an x-axis centered on the zone transition region mid-point (see Figure 17). The relative distance from that point in units of meters is shown, thus making the relationship between *multipath* measurement and transition distance immediately apparent.

3.1.1.2 Multipath Impact on Audio Quality: POLQA Assessment

We have acquired and utilized the POLQA audio quality measurement tool to assess the relationship between *multipath* measurement by the Sofia system and FM broadcast voice quality. A high-level summary of the POLQA system is:[9]

> "POLQA is the global standard for benchmarking voice quality of fixed, mobile and IP based networks. It was standardized by the International Telecommunication Union (ITU-T) as Recommendation P.863 in 2011 and can be applied for voice quality analysis of VoIP, HD Voice, 3G, 4G/VoLTE and 5G networks. The latest version is POLQA v3 (2018)."

The quality score is represented in Mean Opinion Score (MOS) that ranges from 0-5, with a score of 5 being an "excellent" quality. Figure 15 shows a block diagram of the lab test system utilized for this purpose. The wideband (better fidelity) audio files were used in the POLQA testing. These files are sampled at 16 kHz and the wideband audio signal extends to almost 8 kHz.

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[7] Italicized text refers to a measurement parameter, nonitalicized refers to a physical process.
[8] See https://www.denso-ten.com/business/technicaljournal/pdf/2-4E.pdf
[9] http://www.polqa.info/

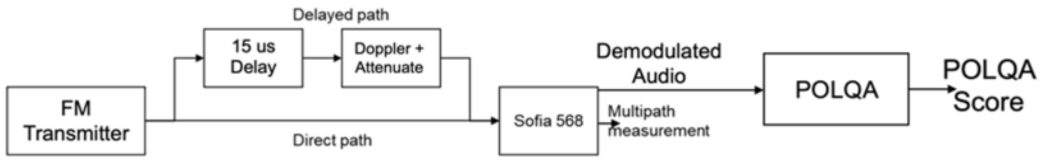


Figure 15. Lab Test System Block Diagram for POLQA Audio Quality Measurement

The results of these tests are shown in Figure 16. Note that MOS measurement was conducted for both male and female voices. For *multipath* values equal to or below 15% both male and female MOS results are above 4.0 (i.e., "Good"). A downward knee occurs around a *multipath* measurement of 20%, where both voices fall slightly below a MOS of 4.0 (i.e., into the "Fair" voice quality region).

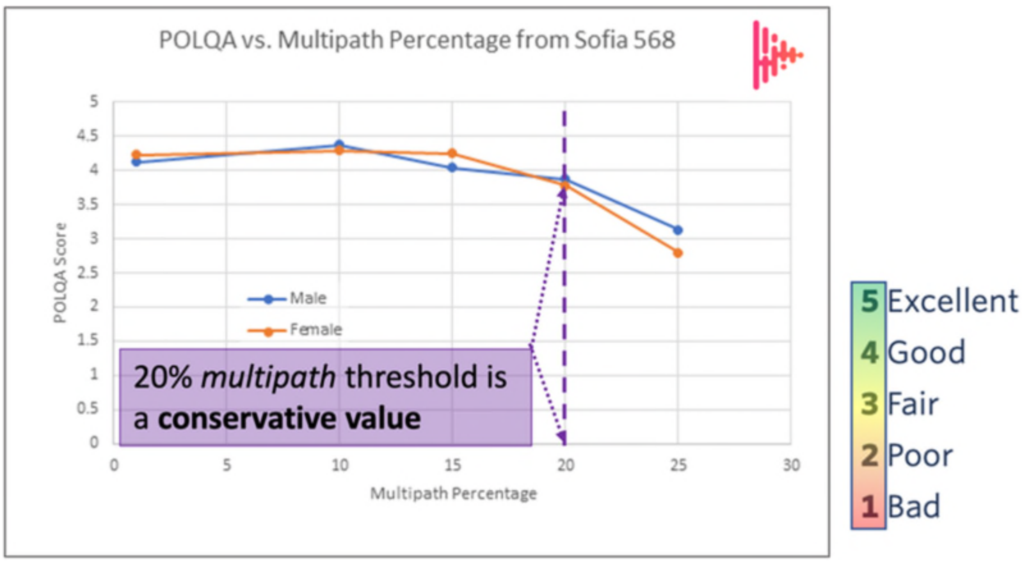


Figure 16. POLQA Audio Quality vs. Multipath % Results

Based on this data we have concluded that the 20% *multipath* threshold is conservative given that this is where the MOS scores fall from "Good" to "Fair" quality. Note that a *multipath* threshold of at least 25% would be required for the MOS scores to fall into the "Poor" quality region.

Using these results, we have generated a color-coded "audio-quality" scale that is overlaid on the *multipath* plots. Through the provision of this information the reader will have context by which to interpret the relationship between the *multipath* transition event and estimated audio quality impact.

3.1.2 Zone Transition Region Size Estimation Methodology

The figure below shows the key stylized characteristics (i.e., a simplified, smoothed representation of the more complex multipath parameter as measured in the field) of the zone transition region size estimation methodology. Based on the above-described listening experience we have defined the *multipath* threshold for degraded audio quality at 20%. Note that the color-coding scale enables interpretation of the *multipath* curve within the context of listener perceived audio quality. In this stylized example the transition size is approximately 80 meters.

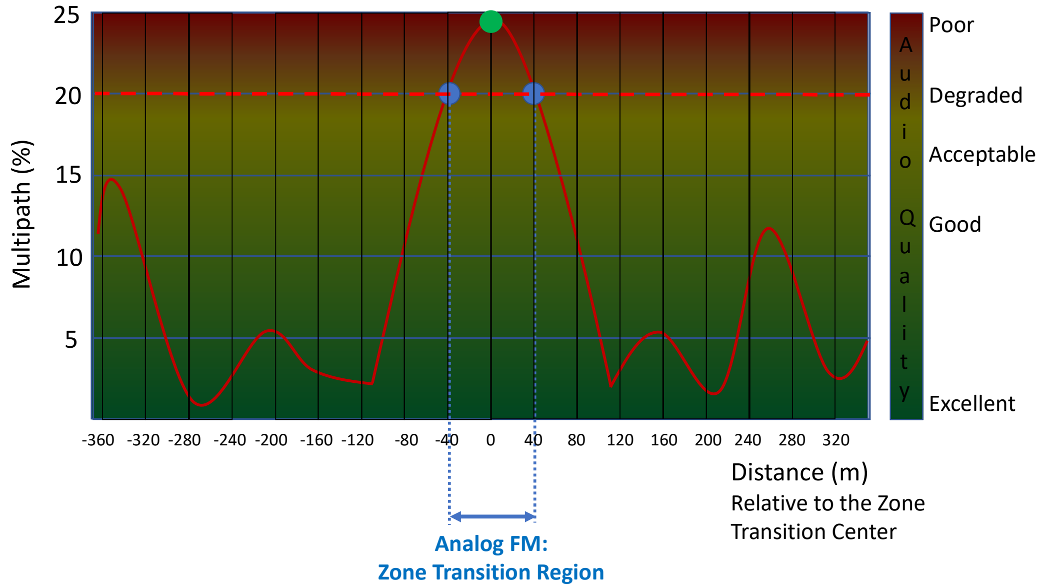


Figure 17. Zone Transition Region Size Methodology Example

Results of using this methodology to conservatively estimate the geo-targeted broadcast zone transition region size are presented in Sections 4.1.1.2, 4.1.2.2 and 4.1.3.2.

3.2 "Interference" in a Dual Content, Geo-Targeted Context

Some commenters on the FM Booster NPRM have utilized the term *interference* to describe events associated with a geo-targeted broadcast zone transition event. While this term of art may be intended to describe potential user response to the transition, it is not well suited to this technical engineering scenario. A detailed discussion of this issue can be found in Section 3.2 of [7].

We therefore will discuss the behavior of the received signal associated with a geo-targeted broadcast zone transition event in terms of "signal stability" as opposed to "interference."

4 RESULTS

The following sections contain technical data associated with evaluation of performance within the context of the Success Criteria (SC) discussed in Section 1.2. Additional details on the scope and extent of measurements can be found in Appendix C.

4.1 General Transition

The results in the following sub-sections focus on the behavior of analog FM broadcasts in a zone transition region.

4.1.1 Area 1: Interstate 20

The transition region is in an urban and suburban flat region traversed by Interstate 20.

4.1.1.1 Multipath Family of Curves

We have generated zone transition *multipath* plots with an x-axis centered on two zone transition mid-points (one for eastbound I-20 and the other for the westbound entrance ramp to I-20). It is important to note from Figure 19 that zone transition *multipath* measurements were taken on numerous eastbound or westbound ramps and lanes associated with Interstate 20 which account for the complexity of the multipath plots in Figure 18. The peak multipath data for these routes is slightly offset from these two reference points. This situation accounts for the range of *multipath* peaks observed in the family of curves. The relative distance from that point in units of meters is shown, thus making the relationship between *multipath* measurement and transition distance immediately apparent. A plot has been generated showing the *multipath* family of curves (Figure 18). No "smoothing" is utilized, so breakpoints in the plot line segments indicate the position of data points (markers were excluded to reduce the level of clutter in this complex plot). Thus, the following figure shows that the Nomad (Sofia 568) *multipath* measurements centered on each 20% *multipath* region for the eastward and westward drives through the transition region.

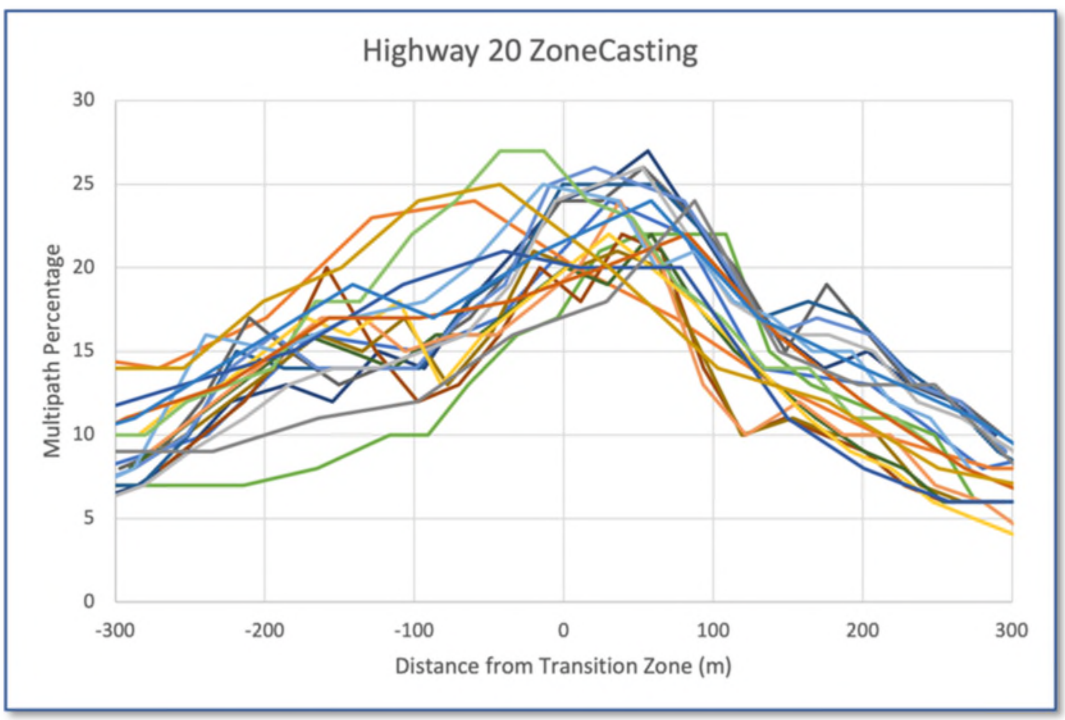


Figure 18. Interstate 20 Transition Family of Multipath Curves

4.1.1.2 Transition Region Size

We determined distance properties of the geo-targeted zone transitions using the methodology described in Section 3.1.2. The zone transitions were separated into two subsets, one for east and the other for the west direction.

Figure 19 was generated by placing markers at the start (i.e., where the *multipath* parameter first exceeds the 20% threshold) and stop (i.e., where the *multipath* parameter falls below the 20% threshold again) locations for each measurement instance. To unambiguously identify these start/stop pairs we have connected each with a light blue line. The partitioning of results between drive directions is easily discernable. Differences in individual line locations are due to use of differing lanes with different distances from the transmitter and different roadway heights, GPS location estimate variability, propagation variability (e.g., driving past a truck located between the measurement car and the transmitter) and the granularity of the measurements themselves.

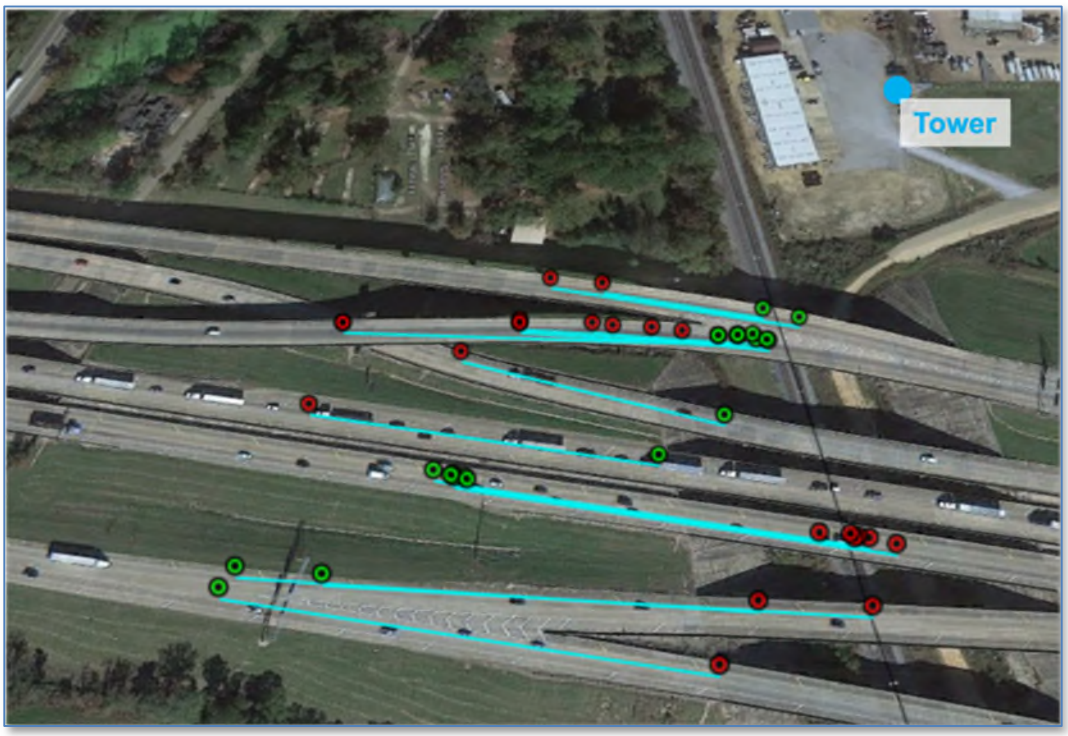


Figure 19. Interstate 20 Start (Green) / Stop (Red) Transition Event Markers

Note that, in general, as the distance from the Tower increases the associated transition region length also tends to increase.

The results of this transition region size assessment are shown in Table 5.

LAT1	LON1	LAT2	LON2	Dist (m)	Direction
32.2747	-90.1670	32.2744	-90.1655	150.4	E
32.2746	-90.1669	32.2744	-90.1654	149.7	E
32.2746	-90.1669	32.2744	-90.1654	141.4	E
32.2746	-90.1669	32.2744	-90.1654	143.9	E
32.2746	-90.1669	32.2744	-90.1656	126.8	E
32.2746	-90.1670	32.2744	-90.1653	159.9	E
32.2743	-90.1674	32.2741	-90.1654	187.3	E
32.2753	-90.1656	32.2755	-90.1666	99.7	W
32.2752	-90.1657	32.2753	-90.1662	44.5	W
32.2753	-90.1658	32.2753	-90.1668	90.0	W
32.2752	-90.1657	32.2753	-90.1661	33.5	W
32.2752	-90.1658	32.2753	-90.1664	55.7	W
32.2752	-90.1659	32.2753	-90.1665	56.4	W
32.2752	-90.1659	32.2753	-90.1675	152.2	W
32.2752	-90.1659	32.2753	-90.1668	76.8	W
32.2754	-90.1658	32.2755	-90.1664	64.4	W
32.2743	-90.1677	32.2742	-90.1658	179.2	E
32.2747	-90.1662	32.2749	-90.1675	132.0	W
32.2742	-90.1677	32.2739	-90.1659	172.3	E
32.2749	-90.1659	32.2752	-90.1670	104.8	W

Table 5. Interstate 20 Transition Region Size Results

Note that 20 zone transition length measurements have been made resulting in an average of 116.1 meters and a standard deviation of 46.9 meters with the East Bound results, i.e., the roadways further from the tower exhibiting considerably larger transition regions than the West Bound results which are nearer to the Tower. The results are further impacted by the height of the roadways which in some cases means they are effectively blocked from a line-of-sight view of the Tower by other roadways.

4.1.1.3 Transition Time

Another rough contextual metric is the time a vehicle will be in the average 116.1 meter length transition zone as a function of speed. For example, at 60 mph a vehicle will traverse 116.1 meters in approximately 4.3 seconds.

4.1.2 Area 2: Highway 80

The transition region is in an urban and suburban flat region traversed by Highway 80.

4.1.2.1 Multipath Family of Curves

See Section 4.1.1.1 for a general description of this data. A plot has been generated showing the *multipath* family of curves (Figure 20).

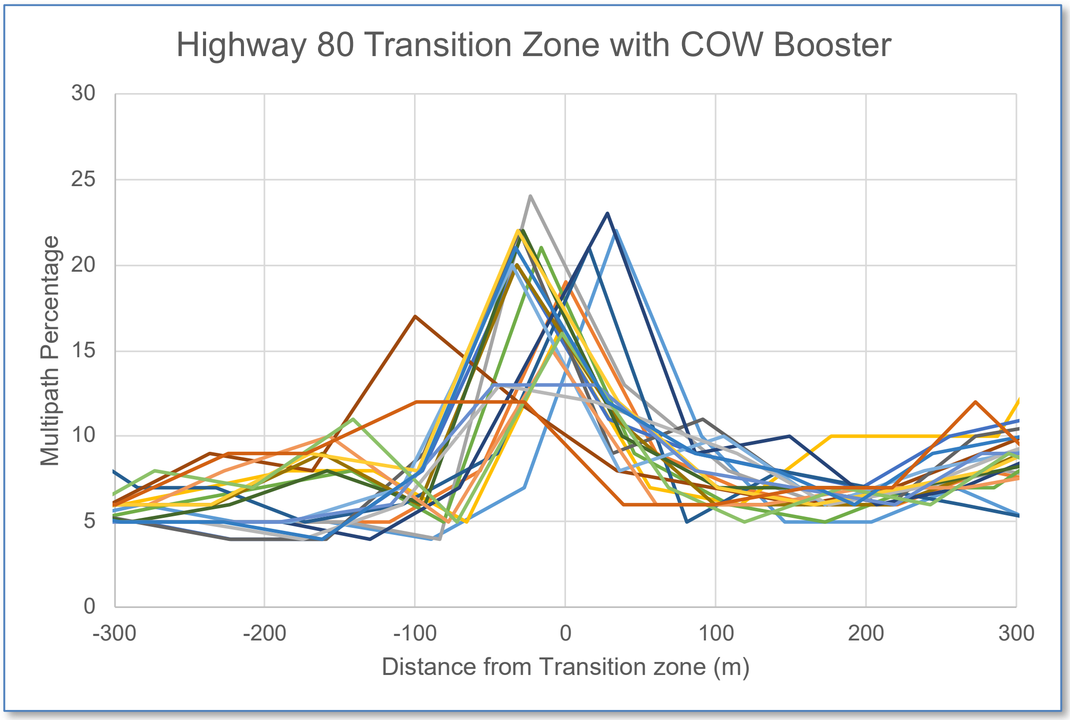


Figure 20. Highway 80 Transition Family of Multipath Curves

Note that numerous *multipath* traces don't exceed the 20% threshold. For these cases the reported transition region size is reported as zero.

4.1.2.2 Transition Region Size

See Section 4.1.1.2 for a general description of this data. Figure 21 was generated by placing markers at the start (i.e., where the *multipath* parameter first exceeds the 20% threshold) and stop (i.e., where the *multipath* parameter falls below the 20% threshold again) locations for each measurement instance.

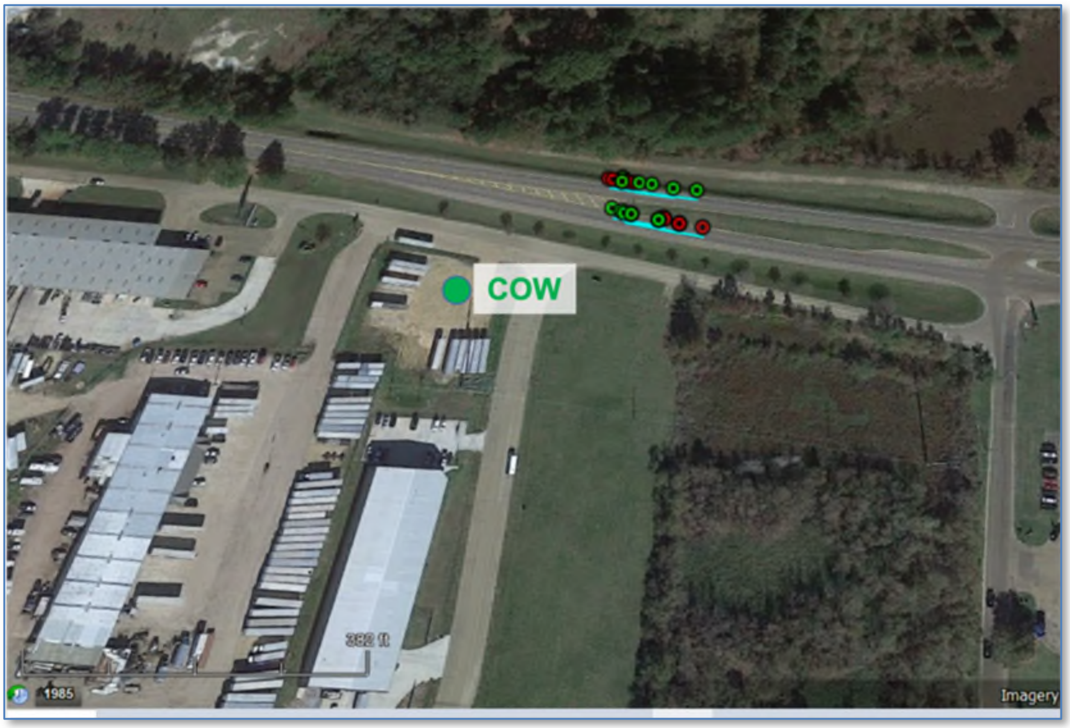


Figure 21. Highway 80 Start (Green) / Stop (Red) Transition Event Markers

The results of this transition region size assessment are shown in Table 6.

LAT1	LON1	LAT2	LON2	Dist. (m)	Direction
32.27887	-90.1626	32.27889	-90.1628	17.7	W
32.27874	-90.1628	32.27867	-90.1624	34.7	E
32.27892	-90.1628	32.27892	-90.1628	0.0	W
32.27871	-90.1626	32.27869	-90.1625	9.2	E
32.27871	-90.1626	32.27869	-90.1625	9.2	E
32.27889	-90.1627	32.27891	-90.1629	19.2	W
32.27874	-90.1628	32.27874	-90.1628	0.0	W
32.27885	-90.1625	32.2789	-90.1628	31.0	W
32.27875	-90.1628	32.27871	-90.1626	19.1	E
32.2789	-90.1628	32.2789	-90.1628	0.0	W
32.27876	-90.1628	32.27872	-90.1626	22.9	E
32.27889	-90.1627	32.27891	-90.1629	11.7	W

Table 6. Highway 80 Transition Region Size Results

Note that 12 zone transition length measurements have been made resulting in an average of 14.6 meters.

4.1.2.3 Transition Time

Another rough contextual metric is the time a vehicle will be in the average 14.6 meter length transition zone as a function of speed. For example, at 60 mph a vehicle will traverse 14.6 meters in approximately 0.5 seconds.

4.1.3 Area 3: Highway 25

The transition region is in an urban and suburban flat region traversed by Highway 25.

4.1.3.1 Multipath Family of Curves

See Section 4.1.1.1 for a general description of this data. A plot has been generated showing the *multipath* family of curves (Figure 22).

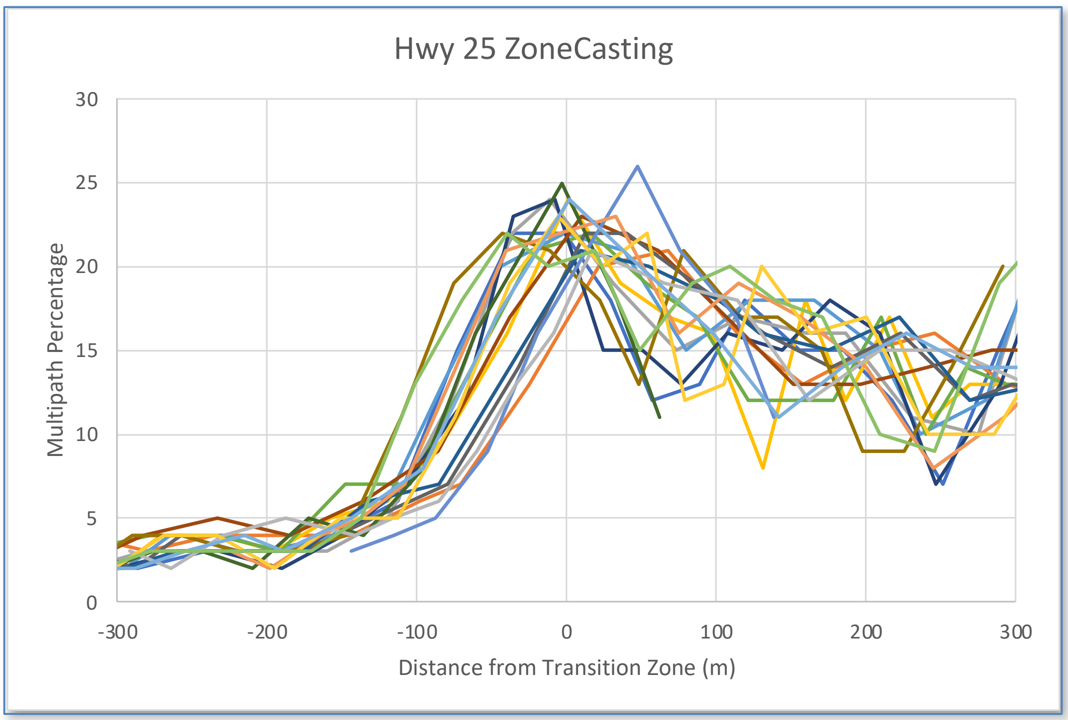


Figure 22. Highway 25 Transition Family of Multipath Curves

4.1.3.2 Transition Region Size

See Section 4.1.1.2 for a general description of this data. Figure 23 was generated by placing markers at the start (i.e., where the *multipath* parameter first exceeds the 20% threshold) and stop (i.e., where the *multipath* parameter falls below the 20% threshold again) locations for each measurement instance.

Figure 23. Highway 25 Start (Green) / Stop (Red) Transition Event Markers

The results of this transition region size assessment are shown in Table 7.

LAT1	LON1	LAT2	LON2	Dist (m)	Direction
32.3329	-90.1346	32.3327	-90.1340	60.0	E
32.3329	-90.1346	32.3327	-90.1339	67.2	E
32.3329	-90.1346	32.3327	-90.1337	89.3	E
32.3329	-90.1346	32.3328	-90.1341	51.1	E
32.3329	-90.1346	32.3327	-90.1339	64.6	E
32.3329	-90.1345	32.3328	-90.1339	58.0	E
32.3329	-90.1345	32.3327	-90.1335	95.7	E
32.3329	-90.1344	32.3327	-90.1335	88.8	E
32.3329	-90.1345	32.3327	-90.1337	78.9	E
32.3330	-90.1342	32.3331	-90.1347	55.5	W
32.3330	-90.1342	32.3331	-90.1347	48.5	W
32.3330	-90.1341	32.3332	-90.1348	69.0	W
32.3329	-90.1338	32.3332	-90.1347	86.8	W
32.3330	-90.1340	32.3331	-90.1348	69.3	W
32.3330	-90.1341	32.3331	-90.1347	52.9	W
32.3329	-90.1345	32.3328	-90.1339	58.0	W
32.3331	-90.1344	32.3331	-90.1347	29.7	W
32.3330	-90.1340	32.3332	-90.1348	74.9	W

Table 7. Highway 25 Transition Region Size Results

Note that 18 zone transition length measurements have been made resulting in an average of 66.6 meters and a standard deviation of 16.6 meters.

4.1.3.3 Transition Time

Another rough contextual metric is the time a vehicle will be in the average 66.6 meter length transition zone as a function of speed. For example, at 60 mph a vehicle will traverse 66.6 meters in approximately 2.5 seconds.

4.1.4 Transition Region Length Compared to Zone Linear Road Length

Our measurement results using the Nomad measurement device's *multipath* parameter, a useful indicator of disruption to a listener's experience, indicate an average zone transition distance across all 50 zone transitions for the three transition regions of 73.9 meters

One method of placing an average 73.9 m length transition region in perspective is to compare this value with the linear length of all roads within the zone. The overall length of roads in the zone area was determined using a query of the OpenStreetMap database using the overpass API interface.[10] First, a polygon outline for the city of Jackson was downloaded from an OpenStreetMap polygon creation website.[11] This polygon approximates the geo-targeted zone (see Figure 4). The polygon is shown in Figure 24.

[10] https://overpass-api.de

[11] Polygon creation for id 109847 (openstreetmap.fr)

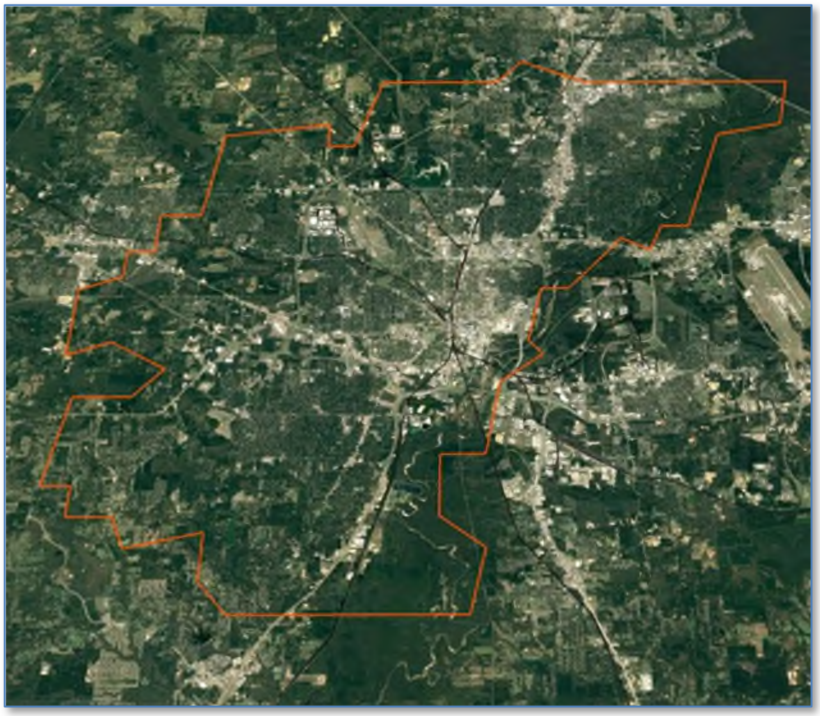


Figure 24. Zone Road Length Estimation Polygon

A query was entered on the Overpass Turbo website to query the Open StreetMap database and calculate road lengths. The road lengths that are returned are shown in the following table. Note that for divided highways the tool returns length for each highway direction.

Type	Length (km)
Highway	133.1
Highway Link	68.8
Primary	43.6
Secondary	140.6
TOTAL	**386.1**

Table 8. Zone Road Lengths

The resulting estimated road length is 386,100 meters. Note that for divided highways the tool counts length twice, one for each direction (e.g., a 10 km stretch of divided highway would be estimated as 20 km, 10 km in one direction plus 10 km in the other). Transition measurements were made on three highways, resulting in an average 73.9 meters transition length. Since the tool double counts divided highway distance, we first multiply the one-way 73.9 meters average by two, resulting in 147.8 meters. We then multiply this value by the three transition areas, resulting in a total transition length of 443.4 meters. Thus, the ratio of the transition region to zone road length is 443.4 meters divided by 386,100 meters, or approximately one part in 871 (the actual ratio is 0.11%).

4.1.5 Transition Region Signal Stability

One concern raised in the FCC's FM Booster NPRM was that there could be areas in which it is possible to move for long distances along a zone transition boundary, thus creating the conditions for regular and objectionable signal instability (i.e., "frequent switches between different audio programs, as determined by the FM receiver's capture effect" see SC ID#25 from Section 1.2.2.1).

This scenario may be theoretically possible, but its occurrence depends on significant system design errors that enable sustained travel on a zone boundary. In actual practice a radio broadcaster has the incentive and ability to design transition boundaries that fall in unpopulated areas, on a body of water or perpendicular to roads and highways. It is our expectation that a broadcaster would never approve any design that places their audience's listening experience at risk.

Regarding the WRBJ design, the zone transition boundary was designed to cut across roads, resulting in a highly controlled, small distance transition region. The balance of this boundary was designed to fall on unpopulated areas without roads, mostly following a riverbed and associated flood plain, i.e., the Pearl River.

Finally, after our extensive field tests in which we experienced 50 geo-targeting broadcast transitions, we did not hear the signal instability of concern occur even once. Clearly this result can't prove that this issue couldn't occur in a poorly designed geo-targeting system, but it certainly is a practical demonstration that a system can be designed and deployed to prevent such an issue.

4.1.6 Mobile Test Environment

Although numerous general concerns were raised in SC #31 (see Section 1.2.2.1), the specific, highest priority issue was that "The FCC must gather significantly more data on ZoneCasting in a mobile environment before moving forward." The data collected and analyzed for this report was dominantly obtained in a mobile environment that included variability in speed, road traversed, vehicle make/model and time of day, among others.

4.2 Commercial Deployment and Coverage

4.2.1 Commercial Deployment and Content

The demo system was designed (as any broadcaster would have the incentive and ability to do), to provide a zone transition region that is minimized in distance and listening impact just as would be the case for a commercial-level deployment. In addition, the demo system was designed to significantly improve the coverage and therefore the consumer listening experience within the geo-targeted zone. Thus, in both key design areas the demo system is "a credible instance of an actual commercial deployment."

4.2.2 Commercial Coverage

We utilized the audio and FM measurement data to assess coverage of the zone by the deployed system. An interior road of the zone was traversed with signal and audio data collection enabled. This allowed general coverage and associated signal quality to be assessed. Coverage measurements were made in the geo-targeted zone with and without the boosters active.

Figure 25 shows the associated measurement data. The first pass was a drive from the point labeled "B" (see Figure 14) with the boosters ON and the second pass was driven from at the point labeled "A" with the Boosters OFF. The RSSI in dBuV reported by the Sophia 568 receiver in the Nomad measurement system is plotted for both the Booster ON (blue) and Booster OFF (orange) conditions. Note that the boosters improve the signal level everywhere along the Highway 55 drive route.

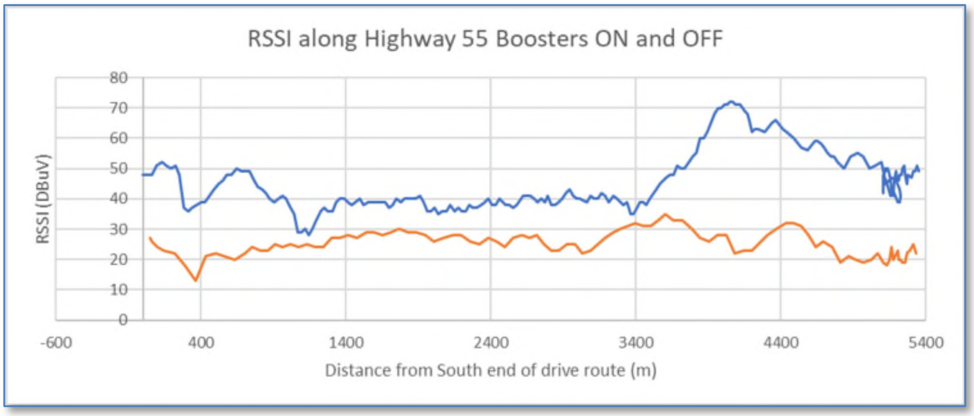


Figure 25. WRBJ Zone Coverage

The average RSSI during the booster OFF drive was 25.2 dBuV. During the booster ON drive the average RSSI was 45.8 dBuV (an average increase of 20.6 dB). These results clearly indicate that the geo-targeting zone created by the boosters significantly improves coverage and signal quality within the zone.

4.3 Emergency Alert System (EAS)

EAS events override all geo-targeted programming. The following block diagram shows how the EAS programming is inserted into both the Main and booster transmitter audio whenever an EAS broadcast is initiated.

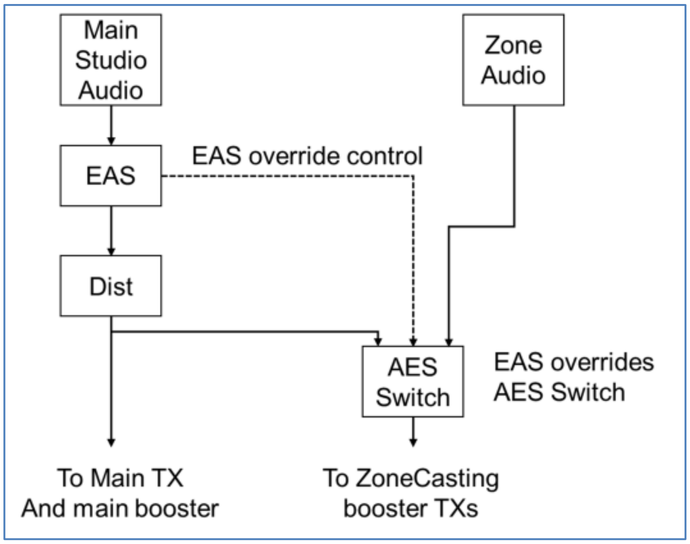


Figure 26. EAS Programming Block Diagram

The signal path for the Main transmitter includes an EAS programming system and an AES audio splitter that provides a replica of the Main audio to the AES switch. When the booster transmitters are not in geo-targeted broadcast mode the AES switch selects Main audio for the booster transmitters. When the booster transmitters are in geo-targeted mode the zone audio is selected by the AES switch. Whenever EAS broadcasts are initiated, the Main audio is replaced with EAS programming. The same control that initiates the EAS broadcast also overrides the AES switch control so that the only the EAS broadcasting is selected for the booster transmitters. The control line is shown as the dashed line in the diagram.

Operation of the WRBJ EAS geo-targeting override was tested simultaneously in two locations to ensure that the EAS broadcast controls function properly. The received audio from the Main booster at the Derrick site was recorded using a smartphone located in Pearl, MS. The received audio from the Derrick booster was recorded on another smartphone in Jackson MS. The EAS broadcast consisted of the standard EAS tones. There was no additional voice EAS message broadcast. The results are shown below. The lower trace shows the monaural audio recorded from the Main programming and the upper trace is from the geo-targeted zone programming.

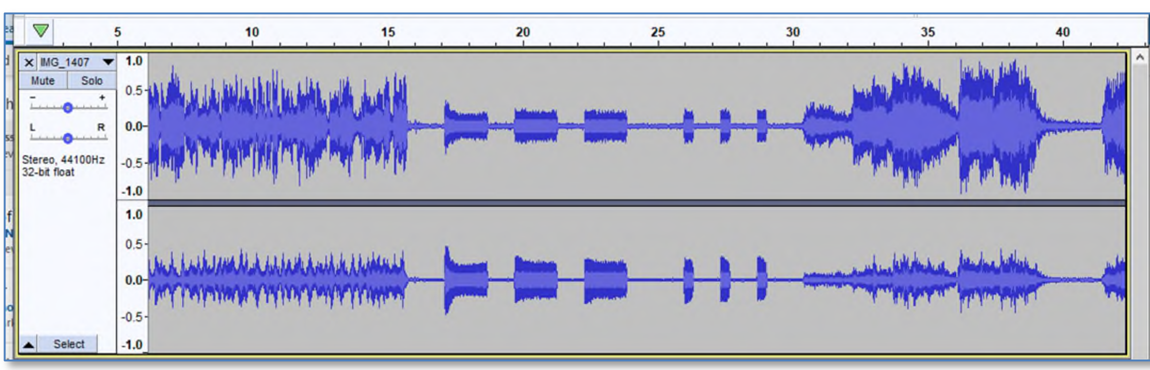


Figure 27. EAS Alert Tone Audio Data with Geo-Targeted Broadcasting

The simultaneous reception of identical EAS tones at these two locations (using two separate measurement systems in two separate vehicles) confirms that geo-targeted broadcasting will not affect performance of the EAS system.

5 CONCLUSIONS

Our following conclusions are organized within the Success Criteria categories of Section 1.2.

5.1 Success Criteria Assessment

The deployment, data collected and analysis of the WRBJ demonstration system was designed to address key stakeholder issues and questions raised in discussions and within the NPRM process. The specific issues (i.e., the Success Criteria) addressed are identified and discussed in Section 1.2. The test results discussed in Section 4 are organized within context of these Success Criteria. We therefore are also organizing our conclusions along these same lines.

5.1.1 General Transition

5.1.1.1 Results

The primary technical issue raised by commenters is the size of the zone transition region in a commercial grade designed and deployed geo-targeted broadcast zone. For this system the transition region was designed to fall in the Pearl River floodplain and avoid residential or commercial areas.

Our data and analysis indicate that a properly designed zone transition can deliver a highly compact region -- a tiny portion of WRBJ's service area -- over which any degraded analog FM audio will be experienced. Our measured results indicate an average zone transition length of 73.9 meters. This distance is insignificant when compared to the total length of roads within the zone (i.e., 386,100 meters). As discussed in Section 4.1.4, the road transition distance is only 0.11% of the total zone road length. We have also observed that the area over which this zone transition occurs is highly stable as is the general received signal behavior.

Regarding the concern that there could be areas in which it is possible to move for long distances along a zone transition boundary, the design of this specific zone has demonstrated that zone transition boundaries can be readily designed to fall in unpopulated areas or across roads and highways. After our extensive field tests in which we experienced 50 geo-targeting broadcast transitions, we did not hear the signal instability of concern occur even once. Clearly this result can't prove the negative, that this issue couldn't occur in a poorly designed geo-targeting system, but it certainly is a practical demonstration that a system can be designed to prevent such an issue. Finally, no sensible broadcaster would accept delivery of a geo-targeting system that behaves in this manner.

5.1.1.2 Experimental Highway 80 Results

The results of this experiment definitively confirm the GeoBroadcast Solutions claim that transition region size is reduced as the booster antenna is moved nearer to the associated road. With the booster located 300 meters from Highway 80 the measured average transition region size is 206.8 meters (see Appendix D). With the booster located 60 meters from Highway 80 the measured average transition region size was reduced to 14.6 meters (see Section 4.1.2.2). A 5 to 1 reduction in distance of the booster to the road resulted in a 14.1 to 1 reduction in transition region size. Thus, the relationship between booster distance and transition region size is, in this case, better than linear and close to a transmitter radius squared relationship.

We conclude that even in flat terrain the transition region size can be significantly reduced by placement of the booster antenna nearer to a road. Thus, a broadcaster can achieve a desired level of transition zone performance through proper system design. Though the additional experiment was not conducted, based on this work, it is concluded that the I-20 transition zone could have been significantly reduced as well by moving the transmitter antenna closer to the interchange roadways.

5.1.2 Commercial Deployment and Coverage

The demo system used commercial grade equipment and was designed to provide a zone transition region that is minimized in distance and listening impact just as would be the case for a commercial-level deployment. In addition, the demo system was designed to significantly improve the coverage and therefore the consumer listening experience within the geo-targeted zone. Thus, in both key design areas the demo system is "a credible instance of an actual commercial deployment" (see SC ID#11 from Section 1.2.2.2). Commercial advertisements were included in the broadcast content.

We utilized the audio and FM measurement data to assess coverage of the zone by the deployed system. The interior roads of the zone were traversed with signal and audio data collection enabled. This allowed general coverage and associated signal quality to be assessed. The results clearly indicate that the geo-targeting zone created by the boosters significantly improves coverage and signal quality within the zone.

The flat topology of the Jackson deployment is near "worst case" for the design and deployment of a geo-targeted zone. This is the case due to the lack of geographic features that can be used to block signal propagation. In addition, due to the number of roads and practical site location constraints the boosters used to create the geo-targeted zone were located at various distances from the road transition regions. In general, the further the distance between the booster and road the larger is the resulting transition region. Thus, the resulting measured average transition length of 73.9 meters provides high confidence that ZoneCasting™ will provide minimal impact on the user listening experience.

5.1.3 Emergency Alert System (EAS)

Operation of the WRBJ EAS geo-targeting override was tested simultaneously in two locations to ensure that the EAS broadcast controls function properly. The received audio from the Main programming was recorded from an automobile receiver (Mitsubishi Outlander) located in Pearl, MS. The received audio from the booster programming was recorded from another automobile receiver in Jackson, MS. The simultaneous reception of identical EAS tones at these two locations confirms that geo-targeted broadcasting will not affect performance of the EAS system.

5.2 Overall Technical Viability Assessment

Having made numerous careful measurements and having assessed the results of these measurements in considerable depth, it is our conclusion that the geo-targeted broadcast system provides both a practical and highly beneficial capability. It is therefore our studied opinion that there is no technical reason that the geo-position zone broadcasting petition before the FCC should not be approved.

REFERENCES

[1] *Amendment of Section 74.1231(i) of the Commission's Rules on FM Broadcast Booster Stations*, MB Dockets 20-401 and 17-105 (December 1, 2020), https://ecfsapi.fcc.gov/file/1202219000352/FCC-20-166A1.pdf .

[2] *Amendment of Section 74.1231(i) of the Commission's Rules on FM Broadcast Booster Stations*, MB Dockets 20-401 and 17-105, Comments of the National Association of Broadcasters (February 10, 2021), https://ecfsapi.fcc.gov/file/1021036085158/NAB Comments NPRM Booster Program Origination 2-10-21.pdf .

[3] *Amendment of Section 74.1231(i) of the Commission's Rules on FM Broadcast Booster Stations*, MB Dockets 20-401 and 17-105, Comments of Beasley Media Group, LLC; Cumulus Media New Holdings Inc.; Entercom Communications Corp.; iHeart Communications, Inc.; New York Public Radio and Salem Media Group, Inc. (February 10, 2021), https://ecfsapi.fcc.gov/file/1021075999676/Joint Comments on Amendment of 74.1231 FM Broadcast Booster Stations 2_10_2021 Final.pdf .

[4] *Amendment of Section 74.1231(i) of the Commission's Rules on FM Broadcast Booster Stations*, MB Dockets 20-401 and 17-105, Reply Comments of the National Association of Broadcasters (March 12, 2021), https://ecfsapi.fcc.gov/file/1031266523188/GBS Reply Comments 3.12.21.pdf .

[5] *Amendment of Section 74.1231(i) of the Commission's Rules on FM Broadcast Booster Stations*, MB Dockets 20-401 and 17-105, Reply Comments of Beasley Media Group, LLC; Cumulus Media New Holdings Inc.; Entercom Communications Corp.; iHeart Communications, Inc.; New York Public Radio and Salem Media Group, Inc. (March 12, 2021), https://ecfsapi.fcc.gov/file/10313261266426/Joint Reply Comments on Amendment of 74.1231 FM Broadcast Booster Stations Final.pdf.

[6] *Amendment of Section 74.1231(i) of the Commission's Rules on FM Broadcast Booster Stations*, MB Dockets 20-401 and 17-105, Comments of Xperi Holding Corporation (February 10, 2021), https://ecfsapi.fcc.gov/file/1021091599267/Xperi ZoneCasting NPRM Comments (Final).pdf.

[7] *KSJO Demonstration System: Geo-Targeted FM/HD Broadcast Technical Report*, MB Dockets No. 20-401 and 17-105, Roberson and Associates, LLC (September 17, 2021), https://ecfsapi.fcc.gov/file/10918302769909/KSJO Technical Report.pdf.

A. Key Contributor Bios

Dennis Roberson, President and CEO

Mr. Roberson is the Founder, President, Chief Executive Officer, and Member of Roberson and Associates, LLC and has over 40 years of industry experience. In parallel with this role, he serves as a Research Professor in Computer Science at Illinois Institute of Technology where he has been an active researcher in the wireless networking arena, a co-founder of IIT's Wireless Network and Communications Research Center (WiNCom), and a co-founder of the Intellectual Property Management and Markets Program. His wireless research has focused on dynamic spectrum access networks, spectrum measurement systems and spectrum management, and wireless interference and its mitigation, all of which are important to the Roberson and Associates mission.

Previously, he served as Vice Provost for Research at Illinois Institute of Technology. Prior to IIT, Mr. Roberson was Executive Vice President and Chief Technology Officer at Motorola. He had an extensive corporate career, which included major business and technology responsibilities at IBM, Digital Equipment Corporation (DEC, now part of HPE), AT&T, and NCR. He has several issued and pending patents. He has been involved with a wide variety of technology, cultural, educational, and youth organizations, including service as Chair of the Federal Communications Commission Technical Advisory Council, and membership on both the Commerce Spectrum Management Advisory Committee and the Board of the Marconi Society. Mr. Roberson serves on the governing and/or advisory boards of several exciting technology-based companies. He is a frequent speaker at universities, companies, technical workshops, and conferences around the globe.

Mr. Roberson holds Bachelor of Science degrees in Electrical Engineering and in Physics from Washington State University and a Master of Science in Electrical Engineering from Stanford University.

Mark Birchler, Senior Principal Investigator

Mr. Birchler joined Roberson and Associates in 2011. He led the deployment of long-term spectrum observatory systems, supported FCC policy development, and provided consultation on dynamic spectrum access coexistence issues. Mr. Birchler has led programs relating to technology and standards associated with DoD/commercial spectrum sharing in the 3.5 GHz and AWS-3 bands, and DARPA spectrum situational awareness. In addition, he has led numerous projects for commercial wireless companies and a cellular operator.

In his 27-year career at Motorola Mr. Birchler contributed to 23 issued patents and led a wireless research department in Motorola Labs.

Mr. Birchler received his Bachelor of Science in Electrical Engineering degree from the University of Minnesota and his Master of Science in Electrical Engineering from Illinois Institute of Technology.

Dr. John Grosspietsch, Principal Engineer III

Dr. Grosspietsch joined Roberson and Associates in 2014 and has 32 years' experience in the industry. He focuses on spectrum compatibility measurement and analysis. He led an extensive measurement campaign investigating co-existence between GPS receivers and LTE networks.

He was a Fellow of the Technical Staff at Motorola Solutions, where he managed research projects in advanced communications systems technologies for mission critical and Smart Grid applications in the Enterprise Mobility Solutions Research Group. He also led a variety of research projects in Software Defined Radio and Cognitive Radio technologies at Motorola Labs. He is currently serving as an Adjunct Professor of Electrical Engineering at Northwestern University.

Dr. Grosspietsch earned a Bachelor of Science in Electrical Engineering, a Master of Science in Electrical Engineering, and a Ph.D. in Electrical Engineering, all from Illinois Institute of Technology.

B. "Success Criteria" Sources

The following information provides details on the "Success Criteria" sources introduced in Section 1.2.1.

Four Broadcast CTOs: These criteria were communicated to Roberson and Associates (RAA) in a meeting on June 15, 2020 with CTOs from the top four FM broadcasting networks. The FM broadcast network CTOs in attendance were: Mike Cooney (BBGI-Beasley), John Kennedy (Audacy), Jeff Littlejohn (iHeart Media) and Conrad Trautmann (Cumulus).

National Association of Broadcasters Comments [2]: The business issues raised in Section II were not included. Items identified in Section III were included. Information from Sections I and IV were also not utilized as they are likely repeats from the document body sections.

Joint Comments [3]: This joint group includes: Beasley Media Group, LLC; Cumulus Media New Holdings Inc.; Entercom Communications Corp (now Audacy).; iHeart Communications, Inc.; New York Public Radio and Salem Media Group, Inc. Due to the length and complexity of this document items were limited to the enumerated information from Section IV and the bulleted information from Section V. Note that the bulleted information from Section V is a subset of the questions posed in the original FCC NPRM document that the commentors believe to be of high priority. This limitation was imposed under the assumption that these sections are reasonable summaries of the detailed discussion that precedes them.

National Association of Broadcasters Reply Comments [4]: Technical issues were primarily selected for inclusion.

Joint Reply Comments [5]: This joint group includes: Beasley Media Group, LLC; Cumulus Media New Holdings Inc.; Entercom Communications Corp (now Audacy).; iHeart Communications, Inc.; New York Public Radio and Salem Media Group, Inc This document highlights concerns and issues raised by Xperi, which is a key stakeholder in HD Radio technology. Therefore, it is these issues and concerns that were selected.

Xperi Comments [6]: Issues in addition to those quoted by the Joint Reply group from Xperi were selected from this document.

C. Data Collection Campaigns

Data was collected during visits to Jackson. The data collected is summarized in the table below.

Campaign Dates	Campaign Description
February 28, 2022	Transition Zone data collection, in-zone and zone contour edge data collection
March 1, 2022	EAS testing, transition zone data collection with advertising content
March 17, 2022	Highway 80 testing
March 18, 2022	Further Highway 80 testing, Interstate 20 entrance and exit ramp testing, Highway 55 Booster OFF testing

Table 9. Data Collection Campaign Trips

Audio files, video files, and measurement data were collected during four visits to the WRBJ coverage area. The summary of the data collected is shown below. The MP3 files were saved by the Nomad measurement software for two Inovonics Sofia 568 receivers. The first receiver saved received FM.

The MP4 files were video files saved from the GoPro cameras used to record the vehicle dashboard.

Data Type	Number Files	Total Recording Length H:M:S	Bytes
Audio mp3 files from Nomad Test Equipment	18	4:30:45	260 MB
Video mp4 files from GoPro dashboard cameras	11	13:45	3.6 GB

Table 10. Data Collection Statistics

Each day after the completion of measurements the audio, video, and data files were copied to an SSD drive. Scripts were run on the original SD Card file directories for the video and audio data to save the file creation and file modification timestamps for later used. A test log was also created that included the time, the measurement type, and the filenames of the audio, video, and the Nomad Campaign name. The files were also backed up onto a second SSD drive.

D. Highway 80 Results with Far Booster

Multipath Family of Curves

See Section 4.1.1.1 for a general description of this data. A plot has been generated showing the *multipath* family of curves.

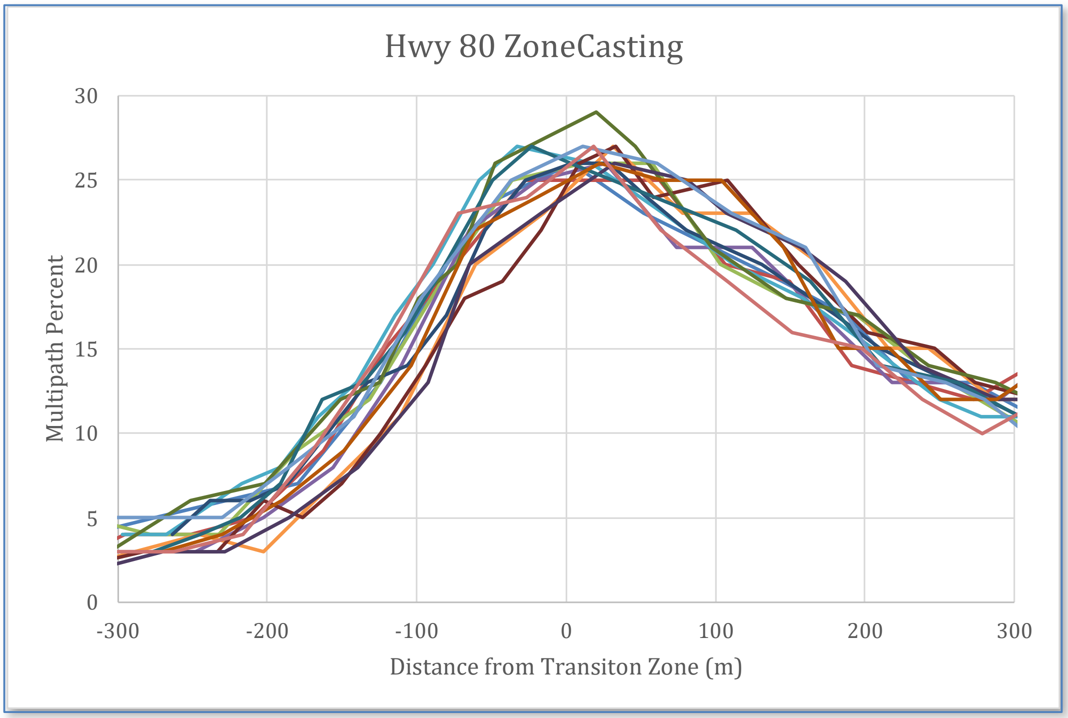


Figure 28. Highway 80 Transition Family of Multipath Curves (Far Booster Location)

Note that this plot displays a significant amount of similarity in general shape and extent for the various *multipath* signals as they pass through the transition region.

Transition Region Size

See Section 4.1.1.2 for a general description of this data. Figure 29 was generated by placing markers at the start (i.e., where the *multipath* parameter first exceeds the 20% threshold) and stop (i.e., where the *multipath* parameter falls below the 20% threshold again) locations for each measurement instance.

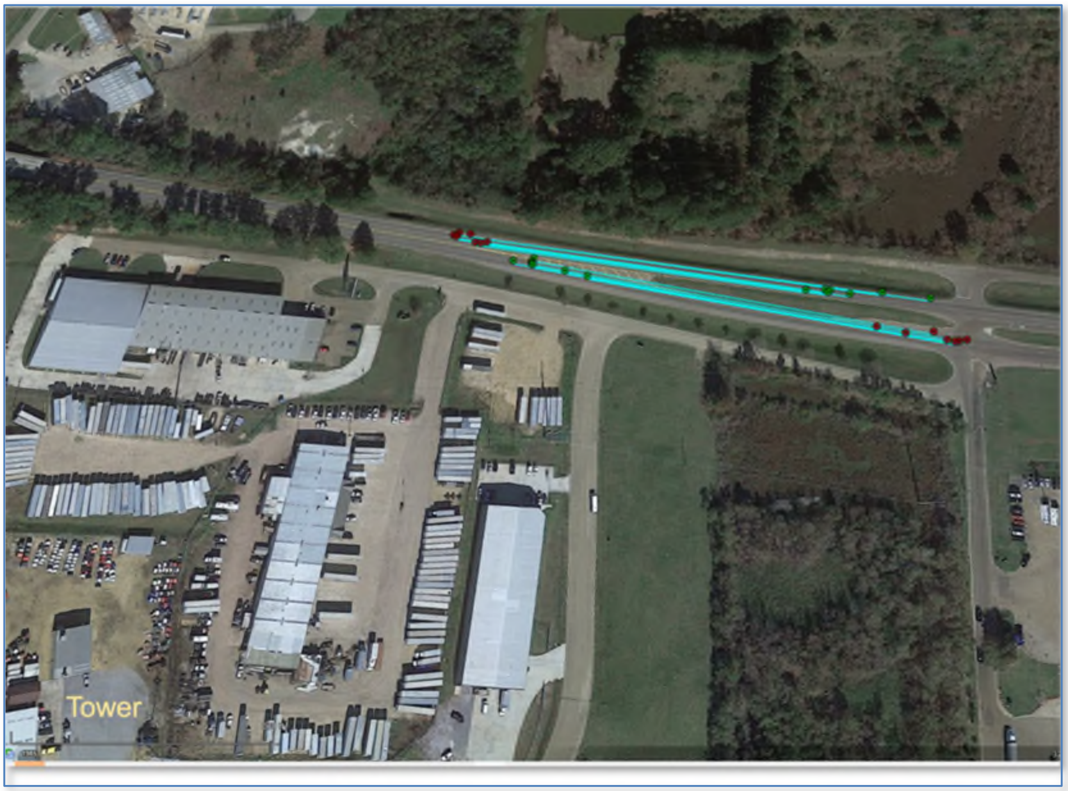


Figure 29. Highway 80 Start / Stop Transition Event Markers (Far Booster Location)

The results of this transition region size assessment are shown in Table 11.

LAT1	LON1	LAT2	LON2	Dist (m)	Direction
32.2789	-90.1633	32.2785	-90.1614	180.5	E
32.2789	-90.1635	32.2785	-90.1613	212.7	E
32.2789	-90.1635	32.2785	-90.1611	230.3	E
32.2788	-90.1632	32.2785	-90.1612	189.4	E
32.2789	-90.1636	32.2785	-90.1611	236.5	E
32.2789	-90.1635	32.2785	-90.1612	223.5	E
32.2789	-90.1635	32.2785	-90.1616	183.8	E
32.2787	-90.1618	32.2791	-90.1639	201.7	W
32.2788	-90.1620	32.2790	-90.1638	178.4	W
32.2788	-90.1618	32.2791	-90.1640	201.0	W
32.2787	-90.1617	32.2790	-90.1638	195.3	W
32.2787	-90.1618	32.2790	-90.1638	187.0	W
32.2787	-90.1615	32.2791	-90.1639	228.0	W
32.2787	-90.1613	32.2791	-90.1639	247.0	W

Table 11. Highway 80 Transition Region Size Results (Far Booster Location)

Note that 14 zone transition length measurements have been made resulting in an average of 206.8 meters and a standard deviation of 21.9 meters.

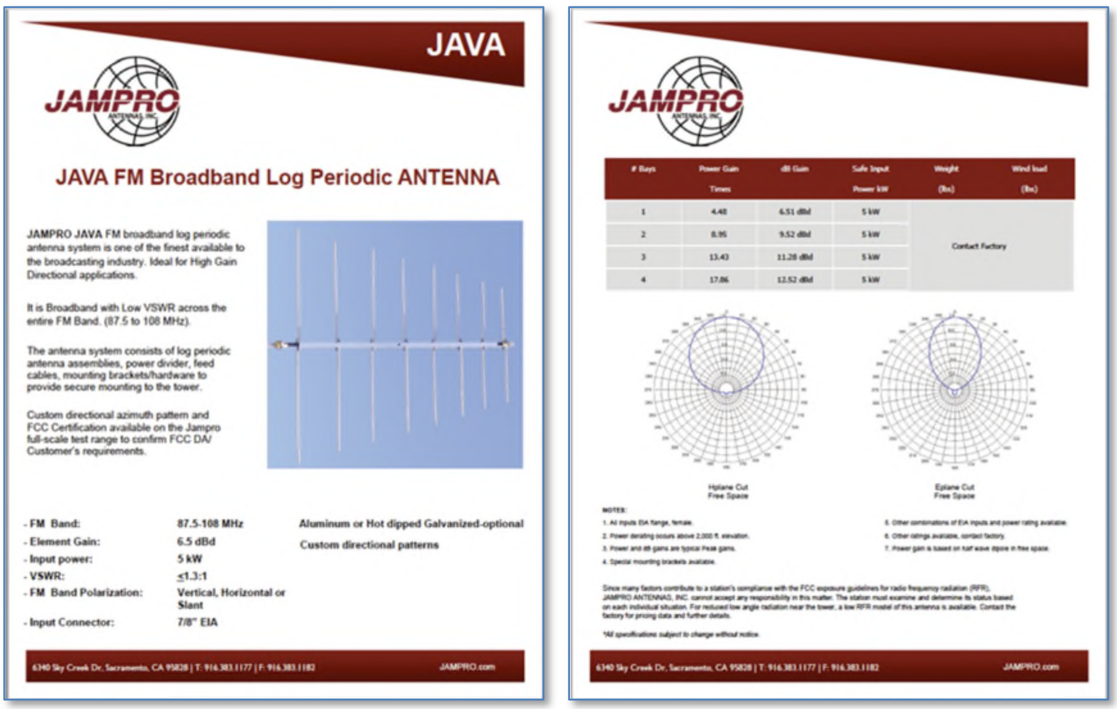
E. Demonstration System Details

Main Transmitter

The main WRBJ transmitter is located near the town of Brandon Mississippi about 15 miles from Jackson. The transmitter power is 6 kW ERP and this places the city of Jackson just inside the 60 dBuV contour.

Booster Details

The antennas used by the booster sites are JAMPRO JAVA FN broadband log-periodic antennas. The datasheet from the JAMPRO website is reproduced below.


JAVA

JAMPRO ANTENNAS, INC.

JAVA FM Broadband Log Periodic ANTENNA

JAMPRO JAVA FM broadband log periodic antenna system is one of the finest available to the broadcasting industry. Ideal for High Gain Directional applications.

It is Broadband with Low VSWR across the entire FM Band. (87.5 to 108 MHz).

The antenna system consists of log periodic antenna assemblies, power divider, feed cables, mounting brackets/hardware to provide secure mounting to the tower.

Custom directional azimuth pattern and FCC Certification available on the Jampro full-scale test range to confirm FCC DA/ Customer's requirements.

- FM Band: 87.5-108 MHz
- Element Gain: 6.5 dBd
- Input power: 5 kW
- VSWR: $\leq$1.3:1
- FM Band Polarization: Vertical, Horizontal or Slant
- Input Connector: 7/8" EIA

Aluminum or Hot dipped Galvanized-optional

Custom directional patterns

6340 Sky Creek Dr, Sacramento, CA 95828 | T: 916.383.1177 | F: 916.383.1182 JAMPRO.com

JAMPRO ANTENNAS, INC.

# Bays	Power Gain Times	dB Gain	Safe Input Power kW	Weight (lbs)	Wind load (lbs)
1	4.48	6.51 dBd	5 kW	Contact Factory	
2	8.95	9.52 dBd	5 kW		
3	13.43	11.28 dBd	5 kW		
4	17.86	12.52 dBd	5 kW		

Hplane Cut Free Space

Eplane Cut Free Space

NOTES:

1. All inputs EIA flange, female.
2. Power derating occurs above 2,000 ft. elevation.
3. Power and dB gains are typical Peak gains.
4. Special mounting brackets available.
5. Other combinations of EIA inputs and power rating available.
6. Other ratings available, contact factory.
7. Power gain is based on half wave dipole in free space.

Since many factors contribute to a station's compliance with the FCC exposure guidelines for radio frequency radiation (RFR), JAMPRO ANTENNAS, INC. cannot accept any responsibility in this matter. The station must examine and determine its status based on each individual situation. For reduced low angle radiation near the tower, a low RFR model of this antenna is available. Contact the factory for pricing data and further details.

*All specifications subject to change without notice.

6340 Sky Creek Dr, Sacramento, CA 95828 | T: 916.383.1177 | F: 916.383.1182 JAMPRO.com

Figure 30. JAMPRO Java FM Broadband Log Periodic Antenna Data Sheet

For the Derrick and Highway 25 sites two antennas are used. The Highway 25 COW site was relocated to be adjacent to Highway 80 during a later measurement phase. The antennas are mounted back-to-back, and each is rotated 45 degrees from horizontal so that they are 180 degrees cross polarized from each other. The figure below shows the two antennas at the Highway 25 mobile site. The antenna on the left points northwest (310 degrees) and the antenna on the right points southeast (130 degrees).

Figure 31. Back-to-Back Antennas at Highway 25 COW Site

Mobile Test System Details

The mobile test system used in the WRBJ testing is shown below. Since WRBJ is an FM-only broadcaster only one Sophia 568 monitor receiver was needed. The Nomad software saves time and location stamped measurement data and MP3 audio. It also saves time and location stamped spectrum analyzer data for the desired FM channel and the first and second adjacent channels. A GoPro was used to capture audio and video from the dashboard entertainment system during selected passes through the transition zones. The measurement system block diagram is shown below.

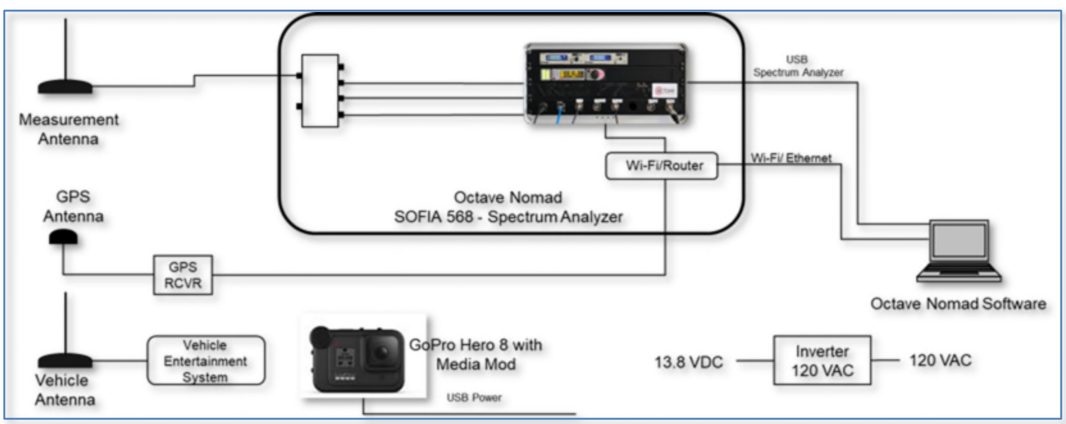


Figure 32. Mobile Measurement System Block Diagram

The measurement antenna is a magnetically mounted vertical quarter wave whip antenna. The antenna is shown in the photograph below.

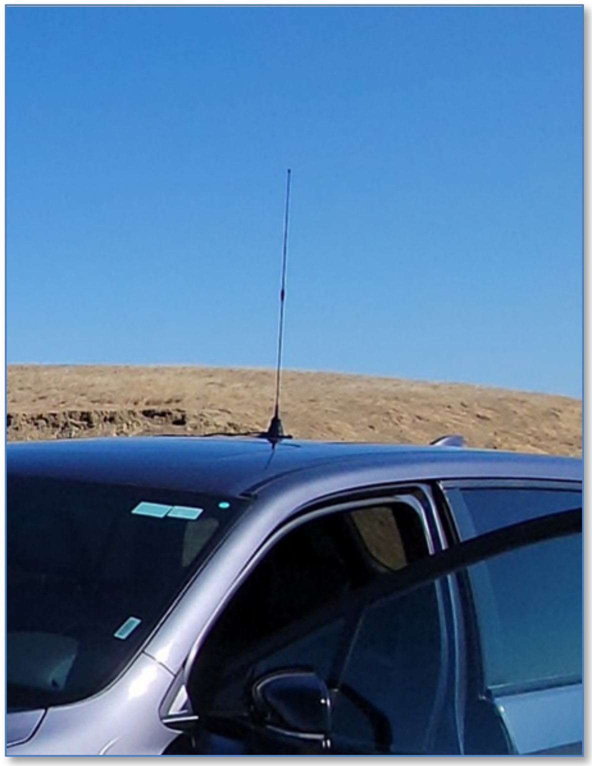


Figure 33. Vehicle Measurement Antenna