Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of Section 74.1231(i) of the Commission's Rules on FM Broadcast Booster Stations	)	MB Docket No. 20-401
	)	
Modernization of Media Regulation Initiative	)	MB Docket No. 17-105
	)	
Amendment of Section 74.1231(i) of the Commission's Rules on FM Broadcast Booster Stations	)	RM-11854

COMMENTS OF THE NATIONAL ASSOCIATION OF BROADCASTERS

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I. INTRODUCTION AND SUMMARY

In December 2020, the Commission issued a Notice of Proposed Rulemaking (NPRM) regarding a proposed rule change that would authorize the origination of distinct, geo-targeted signals using FM booster stations.[1] The Media Bureau now seeks comment on developments in this matter since the comment cycle closed in March 2021.[2] The proponent of the rule change, GeoBroadcast Solutions LLC (GBS), has conducted two recent self-designed field tests of its exclusive technology ZoneCasting™, in San Jose, California with FM Station

[1] *Amendment of Section 74.1231(i) of the Commission's Rules on FM Broadcast Booster Stations*, Notice of Proposed Rulemaking, 35 FCC Rcd 14213 (2020) (NPRM).

[2] *Media Bureau Seeks Comment on Recent Filings Concerning Use of FM Boosters for Geo-Targeted Content*, Public Notice, DA 22-249 (rel. Apr. 18, 2022).

KSJO(FM),[3] and in Jackson, Mississippi with Station WRBJ-FM.[4] Unfortunately, both tests are either invalid and/or useless, and simply do not support GBS's claim that ZoneCasting can be deployed "without negatively impacting the listener experience."[5] To the contrary, these tests – and the fact that more robust, objective tests were not pursued – make clear that ZoneCasting will cause unacceptable interference that harms consumers and undermines the public interest.

It is critical at the outset to understand that there are two general approaches to testing a proposed technology. The first approach is testing a system under a series of real-world challenging scenarios either to discover potential flaws in a system so they can be addressed or to demonstrate a system's efficacy. These kinds of tests are valuable because they seek to approximate real-world conditions and discover a system's true capabilities.[6] The second approach is designed to put a system's best foot forward, to cover up the blemishes, and only show the reviewers what the system's proponent wants them to see. While the FCC and the radio industry critically needed to see and review the first kind of test, GBS's efforts are squarely developed to serve the latter, more cosmetic, purpose. If GBS was genuinely interested in proving its concept, it would have conducted tests that approximate uses in the

[3] Letter from Gerard J. Waldron, Covington & Burling LLP, to Marlene H. Dortch, Secretary, FCC, MB Docket Nos. 20-401 and 17-105, and RM-11854 (Sept. 17, 2021), attaching Roberson and Associates, LLC, "KSJO(FM) Demonstration System, Geo-Targeted FM/HD Broadcast Technical Report" (KSJO(FM) Cover Letter or KSJO(FM) Test Report).

[4] Letter from Gerard J. Waldron, Covington & Burling LLP, to Marlene H. Dortch, Secretary, FCC, MB Docket Nos. 20-401 and 17-105, and RM-11854 (Mar. 30, 2022), attaching Roberson and Associates, LLC, "WRBJ-FM Demonstration System, Geo-Targeted FM/HD Broadcast Technical Report" (WRBJ-FM Cover Letter or WRBJ-FM Test Report).

[5] WRBJ-FM Cover Letter at 5.

[6] A good example of this approach is the extensive testing of HD Radio and involvement of the National Radio System Committee (NRSC) and the entire radio industry. Public Notice, *Comment Sought on National Radio Systems Committee DAB Subcommittee's Evaluation of the iBiquity Digital Corporation IBOC System*, MM Docket No. 99-325 (Dec. 19, 2001).

real world and allowed interested parties to get a complete look under the hood. Instead, GBS has studied ZoneCasting's impact in a few handpicked scenarios, ignored the vast majority of more likely situations, insufficiently addressed ZoneCasting's impact on digital radio, and failed to comprehensively measure ZoneCasting's effects on actual listeners. Regardless, as we discuss in further detail below, even with GBS's cherry-picked scenarios, its results still demonstrate that the public will be harmed if GBS's proprietary systems are permitted to be employed.

To be sure, the National Association of Broadcasters (NAB)[7] has approached this proceeding with an open mind. We supported public consideration of GBS's Petition for Rulemaking proposing ZoneCasting,[8] and commended the FCC for exploring new ways to help local radio remain a robust service for the American public.[9] However, the radio industry's subsequent examination of GBS's proposal revealed certain fatal flaws in GBS's policy rationale. Now, in addition to GBS's flawed policy justifications, the radio broadcasting industry has concluded that GBS's technical claims are defective as well, and permitting ZoneCasting's operation will almost certainly drive listeners away from terrestrial radio and put listeners' safety at risk.

NAB's conclusions on this score are drawn in part from the work of John Kean, Senior Engineer at Cavell, Mertz & Associates, Inc.[10] Mr. Kean is an industry expert at conducting

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[7] NAB is a nonprofit trade association that advocates on behalf of local radio and television stations and also broadcast networks before Congress, the Federal Communications Commission and other federal agencies, and the courts.

[8] Comments of NAB at 5-6, RM-11854 (May 4, 2020).

[9] Comments of NAB at 1-2, MB Docket Nos. 20-401 and 17-105, and RM-11854 (Feb. 10, 2021) (NAB Comments).

[10] John Kean, *Analysis of Technical Reports for ZoneCasting at KSJO(FM), San Jose, CA and WRBJ-FM, Brandon, MS* (ZoneCasting Tests Analysis), attached hereto. NAB's in-house

and evaluating audio listening studies and radio frequency interference studies. Indeed, Mr. Kean previously studied ZoneCasting (and GBS's other product, MaxxCasting) at GBS's request while Mr. Kean served as a Senior Technologist at NPR Labs.[11] Mr. Kean, along with Dr. Ellyn Sheffield, a professor and subjective evaluation expert from Towson University, designed and built a scientific listener-based test system to measure the effects of GBS's technology on the quality of radio audio between the primary and booster stations and develop and recommend acceptable listening parameters. GBS itself has referenced Mr. Kean's expertise regarding its technology long after Mr. Kean's engagement with GBS concluded.[12] Given this experience, Mr. Kean is one of the most, if not the most, qualified engineers to provide an objective, accurate review of GBS's ZoneCasting tests at KSJO(FM) and WRBJ-FM.[13]

As the ZoneCasting Tests Analysis explains, the artificially favorable design of GBS's field tests raises far more questions than the tests purport to answer. Neither test addresses numerous critical issues raised by the Commission in the NPRM or by industry,[14] and both

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technologists, who are prominent broadcast engineers in their own right, separately evaluated the GBS test reports and concur with Mr. Kean's findings.

[11] John Kean, NPR Labs, and Ellyn Sheffield, Melinda Hines, Towson University, *Design Parameters for Analog FM Signal Repeaters Based on Listener Testing*, attached as Exhibit C to Reply Comments of GBS, RM-11854 (May 19, 2020) (NPR Labs Study).

[12] *See, e.g.*, Petition for Rulemaking, GeoBroadcast Solutions LLC, RM-11854, at 5 and 8 (filed Mar. 13, 2020) (GBS Petition); Letter from Gerard J. Waldron, Covington & Burling LLP, to Marlene H. Dortch, Secretary, FCC, MB Docket Nos. 20-401 and 17-105, and RM-11854 (Oct. 9, 2020) attachment at 8.

[13] NAB and NPR jointly commissioned Mr. Kean's evaluation of GBS's tests at KSJO(FM) and WRBJ-FM. Although NPR and NAB agree that Mr. Kean's evaluation shows that authorizing ZoneCasting will harm both listeners and radio stations, we have chosen to file separate comments given the differing missions and perspectives of our respective organizations.

[14] NPRM, 35 FCC Rcd at 14217 (asking a myriad of FCC questions that remain unanswered, including: "What would the listener experience as they moved between zones broadcasting different content or if they otherwise were located near the boundary between two zones (e.g.,

test reports rely on questionable methodologies that skewed the results, thereby negating their usefulness. For example, both tests used "back-to-back" boosters located adjacent to the roadways, and measured ZoneCasting's performance on only a miniscule portion of the roadways in each market, and only on the nearest, most ideal routes for traversing the area where interference occurs. Both tests failed to closely examine ZoneCasting's impacts outside those limited areas, including large areas where harmful and disruptive interference is predicted between the ZoneCasting network and the station's primary signal. These exceedingly favorable scenarios are not a reasonable simulation of ZoneCasting deployments that would be expected under normal or common conditions, and NAB and Mr. Kean are flummoxed that GBS's engineering consultants would hold them out as such. GBS has effectively attempted to "catfish" the Commission by submitting only glowing test results for extremely circumscribed, specifically engineered situations as representative of ZoneCasting's impact on listeners generally throughout a market. Accordingly, the Commission should save itself more time, effort, and energy by swiping left on GBS's rigged tests.

Even under the favorable conditions examined by GBS's consultants, the tests confirm that ZoneCasting will cause unavoidable, unresolvable interference that will harm listeners in large geographic areas.[15] At best, based on GBS's own data, listeners in cars driving 60 mph

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someone whose home was near the boundary (fixed) or who was driving along or close to the boundary (mobile)? Could there be circumstances in which a listener travelling in an automobile moves from a booster zone to the primary zone and then to another booster zone in quick succession? How would these sudden, repeated changes impact the listening experience?"); NAB Comments at 24-29 (listing numerous remaining questions concerning synchronization and booster placement, and ZoneCasting's impact on HD Radio and emergency alerting).

[15] We note with amusement that GBS has described WRBJ-FM's terrain as a "worst-case scenario for constructing zones," without mentioning that the test only studied ZoneCasting's impact in a miniscule portion of WRBJ-FM's service area. Letter from Gerard J. Waldron, Covington & Burling LLP, to Marlene H. Dortch, Secretary, FCC, MB Docket Nos. 20-401 and 17-105, and RM-11854, at 2 (Apr. 18, 2022).

on GBS's most ideal route for traversing the artificially minimized interference area caused by ZoneCasting may experience interference for up to seven seconds.[16] A disruption of this length will certainly confuse listeners and potentially cause them to change channels or switch to satellite or online radio.[17] In other, more likely circumstances, listeners driving 30 mph could lose clear radio reception for up to *13 seconds*, and even longer depending on traffic conditions and the specific route taken through the interference area. For example, listeners traversing the interference area diagonally or driving tangentially along the boundary of the interference area could be subject to much longer disruption.[18] At worst, ZoneCasting could endanger listeners stuck in traffic as they try to escape severe weather or another emergency. Moreover, even under these scenarios, the interference will be widespread because the geographic areas in which the ZoneCasting network and the primary signal overlap may be extremely large (and far larger than the miniscule area GBS actually studied).

It is important to note that, unlike the convenient siting used for GBS's tests, the topography of many radio stations' service areas will not allow them to place boosters at locations that artificially limit the interference caused by geo-targeting. Many stations do not have high-speed highways in their area or may cover areas with large stationary populations in or near the areas of interference caused by ZoneCasting.[19]

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[16] WRBJ-FM Test Report at 29, Table 5.

[17] The ZoneCasting Tests Analysis contains never before publicly released information that highlights the objectionable nature of the ZoneCasting transition areas. ZoneCasting Tests Analysis at 3.

[18] This point must be left to conjecture because GBS did no testing of these important and frequently occurring sets of conditions.

[19] Any such disruption is especially concerning because the majority of radio listening takes place in cars. NAB and others have previously explained the significance of degrading radio quality in cars. NAB Comments at 20; Comments of Xperi Holding Corporation (Xperi) at 5, MB Docket Nos. 20-401 and 17-105, RM-11854 (Feb. 10, 2021). Car manufacturers are

Also, based on Mr. Kean's considerable expertise, NAB understands that consumers will not stomach interference for very long before seeking a new station or service. Most listeners are extremely quick to perceive poor radio service and register their annoyance by changing channels or audio sources in a matter of only ten seconds or so. Thus, any disruption caused by ZoneCasting will confuse or aggravate listeners because the length of such disruption will frequently exceed listeners' tolerance levels. And even if ZoneCasting is implemented on a voluntary basis, the resulting damage will affect *all* radio stations, including stations that do not use the system, as more listeners switch to Sirius XM or Spotify and complain to their car manufacturers about terrestrial radio's resulting shoddy service.

After a careful review that included thorough computer simulations of both the KSJO(FM) and WRBJ-FM tests using industry-standard state-of-the-art VHF signal propagation software, Mr. Kean concludes that ZoneCasting will cause unacceptable signal interference that will harm listeners, and will do so regardless of how carefully the geo-targeting system is installed, operated and maintained. Moreover, as Xperi has pointed out, properly operating and maintaining a sophisticated booster system like ZoneCasting is not a simple matter;[20] thus, if ZoneCasting is actually employed, the Commission can expect even more problems than Mr. Kean predicts.

In reaching this conclusion, Mr. Kean identifies a series of omissions, lop-sided analysis, and skewed reporting regarding both tests, including the following regarding the KSJO(FM) test:

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extremely sensitive to consumer complaints about their entertainment systems. Such complaints can reduce a vehicle's ratings, and encourage carmakers to exclude broadcast radio.

[20] Xperi Comments at 6-12 (describing ways that broadcasting different content on a co-channel FM booster station could affect digital radio reception).

- GBS examined geo-targeting performance using “back-to-back” boosters that were placed so close to the road they were line of sight with the test vehicle, artificially confining the resulting interference, and then seeks to represent these results as applicable to much larger areas. This approach may display a lack of understanding of FM signal behavior.
- GBS examined interference only at highway speeds and along the most ideal route for crossing through the interference area (*i.e.,* at right angles to the transition area), while ignoring other more likely situations that will be unavoidable for many stations, such as routes that cut diagonally through the interference area or run tangentially along the boundary of the interference area. GBS also failed to consider stationary listeners and interference areas in the larger coverage area of the station and its FM1 booster.
- GBS failed to examine the enormous area of potential interference created by the ZoneCasting booster, instead implying without any supporting data that just “0.01617%” of roads will be affected.
- The test did not adequately test the impact of ZoneCasting on HD Radio.
- GBS invents an unsubstantiated “20% multipath threshold” to claim acceptability of ZoneCasting-degraded sound quality, instead of performing listener studies, as is recommended practice. GBS claims that “[L]isteners in FM transition zones experienced no material change.”[21] However, there were no actual listeners involved in the KSJO(FM) test.
- GBS uses a methodology for measuring sound quality that is not intended for measuring the types of audio used in FM broadcasting and reception artifacts of associated with ZoneCasting interference.
- The test only covers a miniscule area, reflecting only a tiny percentage of the situations that stations will face in trying to design a booster system that prevents harm to listeners, and ignoring measurement within the coverage area of the primary station.
- GBS requested and was granted permission to include a high-powered booster in this test, but no mention of this booster is made in the KSJO(FM) Test Report. Exclusion of this booster is consistent with GBS’s reliance on studying only miniscule areas.

As noted above, GBS’s efforts to strategically design the KSJO(FM) test and spin the results do not conceal the fact that ZoneCasting will cause interference that will harm radio listeners. Overall, given the extremely narrow scope of this test and various reporting gaps, Mr.

[21] KSJO(FM) Cover Letter at 2.

Kean determines that the KSJO(FM) test is effectively useless.[22] Similarly, the ZoneCasting Tests Analysis identifies numerous problems with the test at WRBJ-FM:

- As with the KSJO test, GBS also schemed this test to create only the most glowing results by carefully placing back-to-back boosters in locations designed to minimize interference (adjacent to a highway), and presents these results as representative of ZoneCasting's impact over larger areas.
- GBS omits analysis of far more common scenarios that stations will definitely encounter and are more likely to cause interference.
- GBS again only studied the effects of ZoneCasting on the most favorable route for traversing the transition area (*i.e.*, at right angles to the transition area), while ignoring the impacts on listeners travelling diagonally through or tangentially to the areas of interference, or stationary listeners inside or near the examined transition area.
- GBS again failed to examine the effects of ZoneCasting in the larger coverage area of the primary station.
- GBS failed to examine the enormous area of potential interference created by the ZoneCasting boosters, instead implying without supporting data that "only 0.11%" of roads will be affected.
- Station WRBJ-FM has no digital capabilities, so this test adds nothing to address concerns about the impact of geo-targeting on HD Radio.[23]
- GBS repeats that "[l]isteners in FM transition areas experienced no material change,"[24] although no listeners were present during the test and no listening studies were conducted. Of note, GBS collected audio recordings during both tests, but did not make the recordings available for public or Commission review,[25] perhaps because doing so would frustrate its advocacy. Instead, GBS again summoned its phantom "20% multipath threshold" as a surrogate measurement of sound quality degraded by ZoneCasting.
- GBS may have violated the terms of the experimental authority granted to WRBJ-FM, as most of the tested boosters had different coordinates, power, antenna height, type, or orientation from the facilities that WRBJ-FM requested permission to test.[26] Neither Mr. Kean nor NAB could find evidence that GBS or WRBJ-FM received authority to modify the approved test facilities, and it is unclear when the test parameters were changed or why these differences were not reported to the

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[22] ZoneCasting Tests Analysis at 9.

[23] NPRM, 35 FCC Rcd at 14220.

[24] WRBJ-FM Cover Letter at 3.

[25] WRBJ-FM Test Report at 20.

[26] *Id*. at 23-25.

> FCC in the required experimental authorization final report or in the WRBJ-FM Test Report.

As with the KSJO(FM) test, GBS tries to obscure the interference caused by ZoneCasting during the WRBJ-FM test and the harm of such interference to radio listeners. In fact, the interference in the latter was even worse here because the test in Jackson did not benefit from natural terrain shielding as was the case with the San Jose station. The WRBJ-FM Test Report states that the area where ZoneCasting will cause interference may exceed 187 meters, or more than 600 feet, or longer than two football fields.[27] A listener travelling in a car at 25 mph, on the *most ideal* route for cutting through the interference area, could suffer disrupted radio service for about *16 seconds*. Overall, the ZoneCasting Tests Analysis concludes that the WRBJ-FM test, like the KSJO(FM) test, is incomplete, that the data GBS has chosen to report shows that ZoneCasting will cause unacceptable interference, and most importantly, such interference cannot be reliably prevented.[28] The ZoneCasting Tests Analysis thus determines that ZoneCasting is technically unsound and should not be permitted.[29]

NAB asks the Commission to see through GBS's smoke screens and reject GBS's proposal because it will harm listeners, as shown in the ZoneCasting Tests Analysis.

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[27] *Id*. at 29, Table 5.

[28] ZoneCasting Tests Analysis at 16

[29] *Illinois Citizens Committee for Broadcasting v. FCC*, 467 F.2d 1397, 1401 (7th Cir. 2005) ("[T]he FCC has important responsibilities to promote effective radio and television transmission throughout the country, and thus to minimize interference with radio and television signals. . .").

II. NEITHER THE KSJO(FM) NOR THE WRBJ-FM TESTS DEMONSTRATE THAT ZONECASTING IS TECHNICALLY SOUND

ZoneCasting technology is designed to create “zones” within a full-service radio station’s coverage area in which distinct, geo-targeted content is broadcast to listeners using on-channel boosters. This requires overcoming the complex challenge of deploying, operating, and maintaining boosters in a manner that minimizes the objectionable interference caused by simultaneous reception of radio service from the station’s main signal and the booster signal(s), for both analog and digital operations. As discussed below, the two recent GBS tests are hopelessly flawed and too narrowly focused to even begin to address concerns that ZoneCasting will cause unacceptable interference that will harm listeners.

A. Interference from ZoneCasting is not Limited to the Transition Area on the Border Between the Main and Booster Coverage Areas, as GBS Alleges

Readers of the GBS technical reports are asked to believe that the objectionable interference created by ZoneCasting is limited to so-called “transition areas” or “transition regions” which only exist along the perimeter of zone coverage areas, as shown in the rendering below from the WRBJ-FM Test Report.[30] Setting aside GBS’s use of euphemisms for the areas where interference will occur, nothing could be farther from the truth.[31] GBS takes this position throughout as the basis of its test methodology, which is to report only the interference caused by geo-targeting on the zone boundary, and remarkably, at only one (KSJO(FM)) or two (WRBJ-FM) locations.[32]

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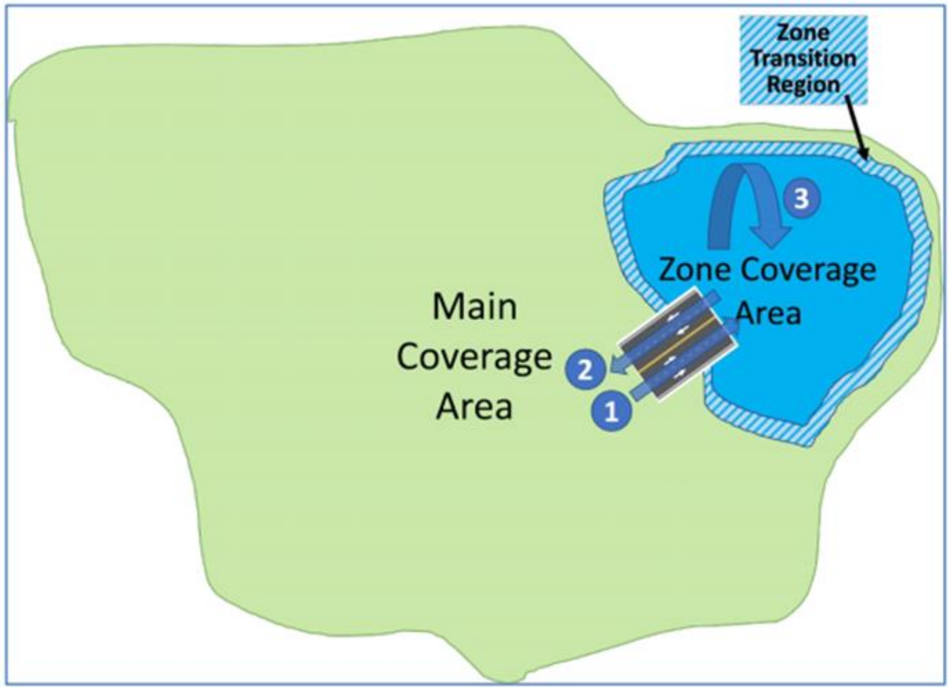
[30] WRBJ-FM Test Report at 2.

[31] KSJO(FM) Test Report at 11, Figure 4, labeling the “zone transition region” as the narrow cross-hatch shaded donut region completely encircling the Zone coverage area.

[32] KSJO(FM) Cover Letter at 1 (“Further, the report shows that the transition areas between zones -- which are entirely within the control of the broadcaster -- can be designed and programmed to take up a miniscule portion of a station’s service area and be infrequent, transitory, unobjectionable, and in most cases unobservable to the listener.”).

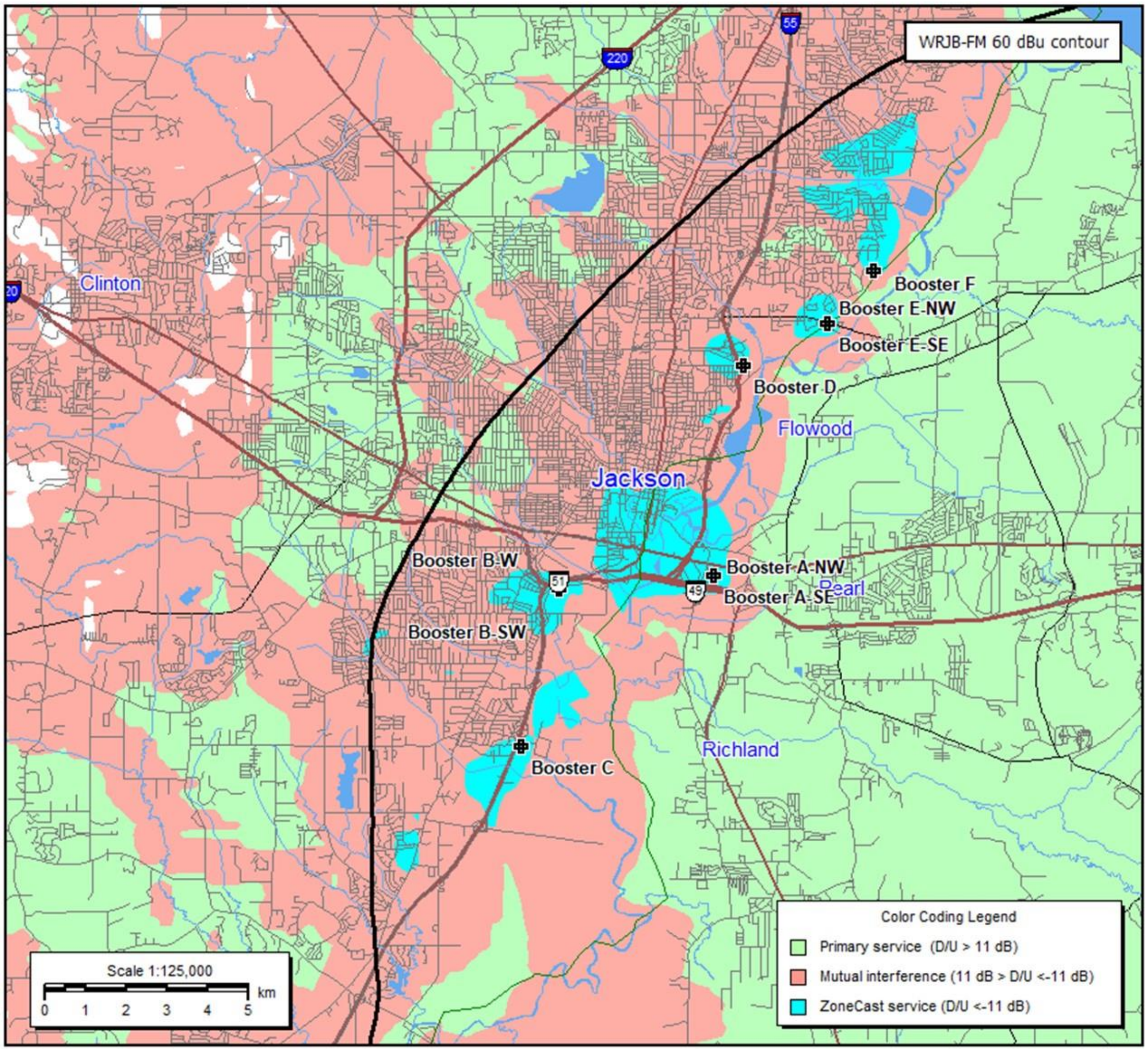


This narrow focus on interference behavior in only a narrow region encircling the zone belies the fact that, as the ZoneCasting Tests Analysis demonstrates, interference caused by the ZoneCasting boosters will be widespread and predictable outside that narrow region.[33] As defined by GBS, transition areas exist only where "the power of the localized zone signal is similar to the power of the main FM broadcast signal."[34] However, the ZoneCasting Tests Analysis clearly demonstrates that interference will occur over large areas and is not limited to the zone border. Both GBS reports totally ignore this fact and provide no test data or analysis to characterize this widespread predicted interference. This is not surprising because doing so would require GBS to acknowledge the truth about booster-generated interference and contradict its primary assertion that the expected interference from ZoneCasting is limited and controllable, when in reality it is neither.

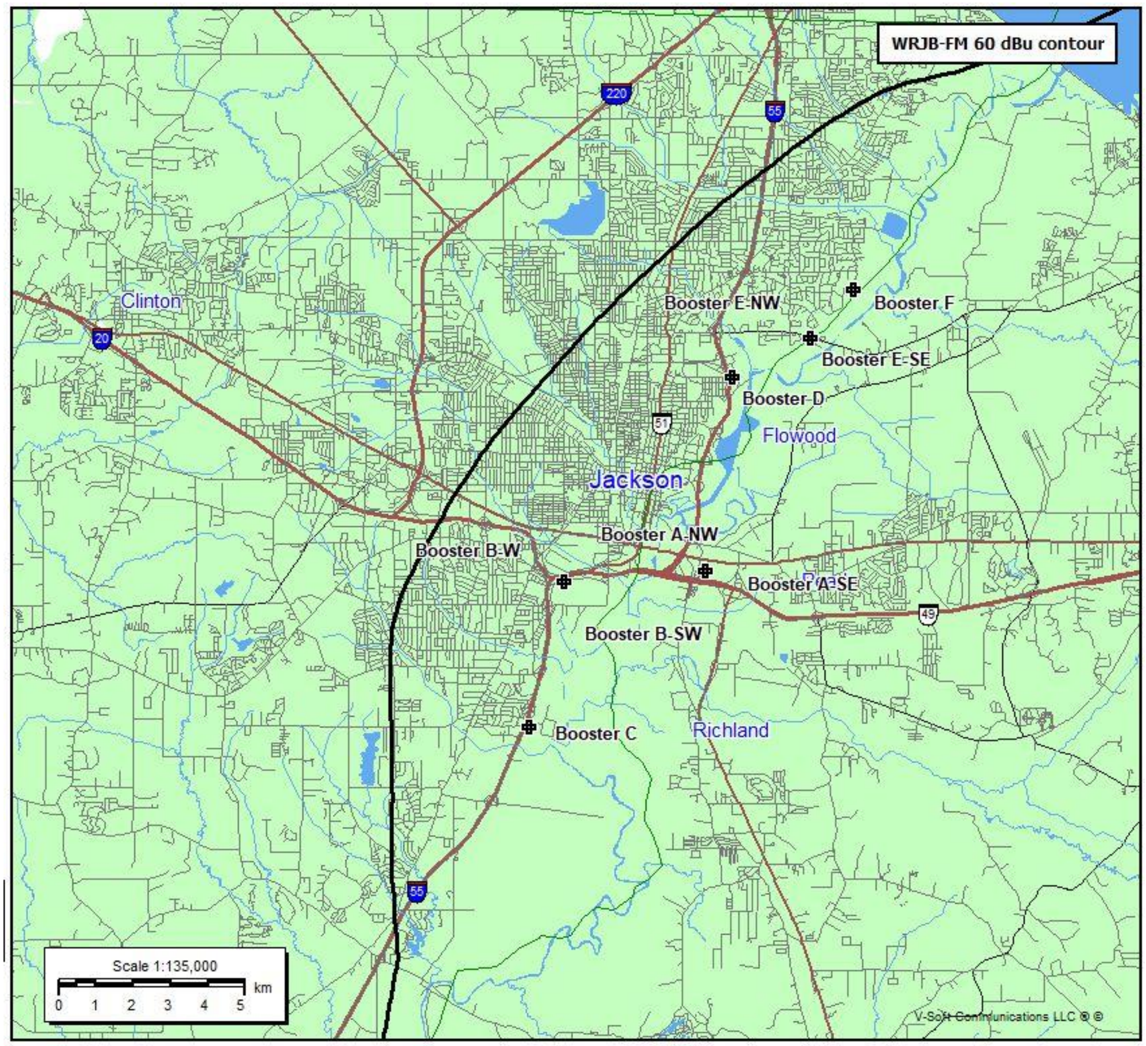
[33] ZoneCasting Tests Analysis at 16

[34] WRBJ-FM Test Report at 2.

To appreciate the magnitude of the GBS deception, consider this map of a portion of the WRJB-FM coverage area (ZoneCasting Tests Analysis, Figure 10), which highlights in red the areas of interference within and surrounding the zone created by the boosters, which are of course responsible for the interference:



Mr. Kean generated this map using the engineering specifications of the WRJB-FM booster network provided in the WRBJ-FM Test Report (booster service contours have been omitted for clarity). This map clearly shows that, rather than a continuous narrow ring around each of the booster coverage zones, the transition region is discontinuous and widespread. The red areas of interference in this map represent an expected interference threshold ratio of 11 dB D/U, which is 9 dB worse than allowed for co-channel interference under FCC allocation rules. For comparison, the same map as shown above was generated with the boosters turned off and is shown below. The absence of the red interference areas here highlights the deleterious effect of the boosters shown in the earlier map.



This situation, where a ZoneCasting booster is interfering with a main channel signal broadcasting different content at an 11 dB D/U ratio, was studied in 2013 by Mr. Kean while employed at NPR Labs, as part of a laboratory-based listening project for characterizing listener opinions about ZoneCasting interference.[35] Mr. Kean, using a scientifically-based subjective evaluation listening study, determined that only 9% of listeners would keep listening to the type of signal depicted in the red regions above, and that the audio quality in these regions was found to have a mean opinion score (MOS) of 1.6, which is poor. This is a far cry from GBS's claims.

Returning to GBS's proffered data, Figure 4 in the KSJO(FM) Test Report is a stark illustration of the woeful inadequacy of GBS's data collection effort – a single route into and out of the zone coverage area, and nebulous, undocumented testing within the zone and in the terrain-shielded, strong signal area of the booster where no interference would reasonably be expected. Figure 4 also obscures GBS's attempt to "stack the deck" for the test routes labeled "1" and "2" by placing back-to-back, highly directional antennas right on top of where the measurements were made. Further, Figure 4 demonstrates GBS's myopia regarding the transition region as only existing along the perimeter of the zone, a misleading depiction as demonstrated in the many examples of predicted interference in the ZoneCasting Tests Analysis.

GBS inadvertently shines a light on the inadequacy of its own data when reviewing the transition area test data collected for the KSJO(FM) Test Report, obtained on a single stretch of highway (I-680) traversed multiple times. Table 5 of this report states that there are 621 km of roadway within the zone being studied and Figure 13 shows that there are multiple roadways crossing between the zone and main signal areas.[36] It is inconceivable that GBS would acknowledge the extent of the zone on the one hand but on the other hand provide

[35] ZoneCasting Tests Analysis at 3.

[36] KSJO(FM) Test Report at 25-26.

data on only a single, short route as evidence of acceptable performance for this ZoneCasting system. Essentially, GBS insults the Commission's ability to accurately assess the impact of interference caused by geo-targeting in this exercise.

It also bears mentioning again that the routes used for data collection in both tests are closely adjacent to a back-to-back booster installation, which by design will create an extremely short transition area and is wholly unrepresentative of the general architecture of ZoneCasting. This fact alone dooms both tests as all of the presented data only reflects the back-to-back booster-antenna configuration and not typical ZoneCasting behavior.

B. Subjective Evaluation Studies Which Form the Basis of GBS Testing are Mis-applied to ZoneCasting and Render Both Tests Useless

GBS repeatedly cites a subjective evaluation test program funded by GBS and conducted by NPR Labs and Towson University that was designed to establish the level of interference that listeners find objectionable, and purportedly establish a scientific basis for identifying the size of the transition area observed during the KSJO(FM) and WRBJ-FM tests. For example, GBS's initial Petition for Rulemaking states:

> The parameters for ZoneCasting were verified by simulations of transmitted FM signals at NPR Labs, and these simulation results were then evaluated by a large group of listeners in controlled subjective testing at Towson University. These parameters define the RF interference (C/I+N) ratios in both stereophonic and monophonic FM transmission, for fixed and mobile reception. Extensive network design work at NPR Labs was used to identify the power and height for the ZoneCasting boosters under a variety of primary station types and terrain conditions. By using appropriate parameters for each of main transmitter and each of the boosters, harmful interference within the target area of the zone can be effectively eliminated.[37]

In the course of preparing these comments, NAB has learned that GBS's claimed scientific basis for eliminating harmful interference caused by ZoneCasting, based upon data purportedly obtained by NPR Labs, does not exist. On the contrary, there exists a set of data,

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[37] GBS Petition at 8.

never publicly disclosed until now, produced by NPR Labs at the behest of GBS back in 2013, which focuses on the performance of ZoneCasting in transition areas. This data proves that the performance of ZoneCasting is poor and objectionable to listeners.

The ZoneCasting Tests Analysis provides details of the testing conducted by NPR Labs on behalf of GBS. In sum, in 2013, NPR Labs worked with Towson University to study both ZoneCasting and simulcast single-frequency network (SFN, referred to by GBS as MaxxCasting) booster signal reinforcement. The test results on the MaxxCasting SFN configuration, published in the *Proceedings of the 2013 NAB Broadcast Engineering Conference*, demonstrated that when properly implemented, a simulcast booster can improve reception without creating widespread, excessive interference. On the other hand, the test results regarding ZoneCasting were never published, and interestingly, never referenced by GBS in any of its submissions to the FCC. These results, some of which are included in ZoneCasting Tests Analysis, demonstrated that ZoneCasting would cause unacceptable interference to listeners,[38] and never used as claimed by GBS to "identify the power and height for the ZoneCasting boosters under a variety of primary station types and terrain conditions."

C. No Listening Tests are Included in Either Test Report and the Objective Listening Test Measure Used by GBS is Misapplied to ZoneCasting

The opinion of listeners is the most important factor in evaluating the impact of RF interference on FM radio listening. Subjective evaluations, in which audio recorded under the interference conditions of interest is collected and presented to a statistically significant number of qualified listeners in a structured and scientifically-based manner, are used to assess the impact of the interference.

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[38] ZoneCasting Tests Analysis at 4.

It is notable, but not surprising, that neither of the GBS reports includes any listener-based data. In lieu of asking listeners to assess the audio quality while in a transition area, GBS relies on an objective measurement method, "POLQA Assessment," which they applied to audio samples obtained in regions of high "multipath" as established by the Roberson test gear.[39] This evaluation process is twice doomed as Roberson misapplies both the POLQA assessment and the multipath measurement characterization, rendering the data presented in the reports as highly questionable if not completely unusable. As explained in the ZoneCasting Tests Analysis: "[The authors] do not appear to realize that ZoneCasting involves an entirely different version of program audio from the host station's primary signal, which is properly called co-channel interference – not 'multipath.'"[40]

The POLQA audio quality measurement tool is designed around an ITU-T recommendation, P.863, which cautions that there are a number of "factors not validated" which are factors the measurement tool has not been shown to work with. A number of these factors, including "multiple simultaneous talkers" and "music input to a codec" are highly relevant to and likely to be found in the audio samples collected by Roberson.[41] As noted above, actual listening tests relevant to ZoneCasting were conducted by NPR Labs in 2013 and, as described in the ZoneCasting Tests Analysis, revealed that listeners were highly critical of the audio impairments created by the sort of interference that is created by ZoneCasting. Interviews with the listeners revealed that "the intermittent 'break-in' of the

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[39] Roberson teases offering insight into their ideas regarding the use of multipath measurement in the KSJO(FM) report, stating, "Although a few parameters have utility in this domain, the multipath measurement is clearly the most reliable and useful (see Appendix E)," however, no Appendix E is included in the report. KSJO(FM) Test Report at 18.

[40] ZoneCasting Tests Analysis at 18.

[41] *Id*.

primary audio by different content from the ZoneCasting signal was far more annoying than equal-level bursts of neutral noise and distortion in the audio."[42] It is telling that GBS elected to never reveal these NPR Labs ZoneCasting test results nor ever referred to them in their numerous FCC filings.

D. HD Radio Testing Documented in the GBS Test Reports is Completely Inadequate and Leaves Open Numerous Critical Questions

GBS has conducted an extremely limited amount of testing of ZoneCasting using HD Radio digital radio signals. Moreover, such testing was performed only during the KSJO(FM) test, with no additional testing during the more complex deployment tested at WRBJ-FM, even though numerous questions regarding ZoneCasting's effect on HD Radio remained unaddressed after the KSJO(FM) test. Xperi, which developed HD Radio, remains extremely concerned about ZoneCasting,[43] as do radio broadcasters that have invested heavily in digital radio facilities.[44]

Incredibly, by observing HD Radio performance on a single test route, right next to a location utilizing back-to-back directional booster antennas which guarantee an unnaturally sharp transition area, GBS concludes that the "HD1 transition size is at least an order of magnitude smaller than that for analog FM and is, in effect, instantaneous and therefore unmeasurable."[45] This conclusion is unreasonable and unsupported by the KSJO(FM) test. It is unimaginable and may contradict the most basic tenets of scientific practice to reach such

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[42] *Id*. at 19.

[43] Xperi Comments at 6.

[44] Joint Reply Comments of Beasley et al at 6-9, MB Docket Nos. 20-401 and 17-105, and RM-11854 (Mar. 12, 2021).

[45] KSJO(FM) Test Report at 20 and 28.

a sweeping conclusion based on virtually no evidence.[46] It is also absurdly convenient because GBS admits that the only measure of transition areas used in its reports, the so-called "multipath threshold" measurement, is inapplicable to HD Radio signals. Therefore, GBS should have used an appropriate method to conduct any HD Radio measurements.[47]

Furthermore, while the KSJO(FM) Test Report describes the audio and HD Radio reception indicator behavior of the receiver as the transition area is traversed, brief and only dubious mention is made of the metadata behavior,[48] despite the apparently significant efforts undertaken by GBS to observe and document such metadata. Specifically, GBS claims that it has "collected GoPro video files for the zone transitions across numerous vehicles."[49] In today's "connected cars," the content, quality and dependability of radio station metadata are critical factors as radio broadcasters compete directly on the dashboard with internet-sourced audio services that set new standards for consistent and relevant metadata that listeners demand.

The KSJO(FM) Test Report distills the results of these metadata observations down to a series of three figures showing a single receiver display and allegedly demonstrating that the metadata did not change while the receiver was traversing the transition area.[50] The last

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[46] *Code of Ethics for Engineers*, National Society of Professional Engineers, available at https://www.nspe.org/resources/ethics/code-ethics.

[47] KSJO(FM) Test Report at 19 (stating that "it is not feasible to set a meaningful multipath threshold for estimating HD Radio transition region size. This is because there is no discernable relationship between the multipath value and perceived audio quality [in the HD Radio signal].").

[48] *Id*. at 30.

[49] *Id*. GBS contends earlier in the report, in their description of the testing research conditions and methodology, that test radios included ". . . models from different manufacturers which were outfitted with the equipment to measure received signal and audio/video/Metadata quality for the FM and HD Radio signals." KSJO(FM) Cover Letter at 2.

[50] KSJO(FM) Test Report at 31, Figures 17-19.

figure purports to show metadata particular to the zone transmission and hence serves as evidence of reception of the HD Radio zone transmission; however, the "HD indicator" highlighted in the first figure in the series, is suspiciously absent from the figure supposedly showing reception of the Zone-based HD Radio signal. NAB has conducted extensive metadata investigations in the field using automotive receivers and has observed a wide variation in metadata behavior, and based on this experience, finds it beyond credulity that the meager discussion in the KSJO(FM) report could accurately capture the transition area metadata behavior if GBS's test are in fact accurately described in the test report.

Nor is digital multicast channel performance acceptable, even under the unrealistic scenario tested at KSJO(FM). Not surprisingly, the multicast channel audio muted while the transition area was traversed, resulting in seven seconds of silence. The conclusion reached in the report is that the main signal and booster signal "Exporters" need to be synchronized, indicating that: "Efforts are underway to develop means to synchronize HD Exporters that could reduce the duration of HD2 signal loss."[51] Absent such developments and reliable operations, ZoneCasting will have a devastating impact on digital radio service, to the detriment of both listeners and stations.

III. THE ZONECASTING TESTS AT KSJO(FM) AND WRBJ-FM PROVE THAT ZONECASTING SHOULD NOT BE AUTHORIZED

Prior to the ZoneCasting test at KSJO(FM), the only test of ZoneCasting referenced by GBS that may have any relevance was conducted in 2016 at WIIL(FM) in Milwaukee, Wisconsin, although it remains unclear whether this test used a previous or current version of ZoneCasting. Either way, GBS made it virtually impossible for the public to assess this exercise by failing to address or define certain important parameters, such as listeners' opinions of the

[51] *Id*. at 29.

sound quality degraded by ZoneCasting and the routes or speed of the test vehicle. Yet, despite these gaps, and GBS's testing of only conditions that supported its advocacy, the WIIL test still revealed troubling interference along three driving routes through the areas where the contours of the station's main signal and booster met that lasted from 12 to 30 seconds.[52] Interference to this degree will clearly cause significant disruption to listeners.

Nothing in the more recent tests at KSJO(FM) or WRBJ-FM resolves this problem. To the contrary, these tests only confirm the serious harm that allowing geo-targeting using FM boosters will cause listeners. As described above, GBS has only examined back-to-back boosters located very close to a highway and tested for interference along only the most ideal driving routes for traversing the interference area, and only at high speeds. In addition, both KSJO(FM) and WRBJ-FM offered uniquely favorable conditions, as the former test area enjoyed natural terrain shielding that helped to limit the interference caused by ZoneCasting, and the latter test areas are located in a fairly unpopulated area. Moreover, it seems that GBS may have only submitted data that supported its wished-for results.[53] And at WRBJ-FM, GBS apparently tested using booster facilities that differed from those authorized by the FCC.

In addition, although GBS characterizes ZoneCasting's effect on listeners as immaterial,[54] there were no listeners present during either test and listeners have never rated any of the audio samples obtained during the test. Nor has GBS conducted industry-standard listening studies. GBS collected audio recordings of both tests but declined to submit them for

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[52] Beasley et al. Comments at 9-12.

[53] The KSJO(FM) Test Report states: "The zone transition region was traversed over 60 times at variable speeds and at various times of day using several vehicle makes/models, with 32 randomly selected for transition length measurements." The implication is that 28 examples of audio quality in the transition area were set aside. KSJO(FM) Test Report at 2.

[54] WRBJ-FM Cover Letter at 3.

review by the FCC or the public.[55] Even more damning, it appears that almost a decade ago, GBS squashed and misrepresented listening studies conducted by NPR Labs that proved ZoneCasting causes objectionable interference to listeners.[56]

At the same time, GBS leaves unanswered many critical technical questions asked by the FCC and industry stakeholders. For example, what would a listener experience as they travel near or along the intersection between two zones while the primary station and booster are airing different content, and how would stationary listeners located in homes near this intersection be impacted?[57] Or how will ZoneCasting impact radio listening throughout a station's listening area, given that GBS has only studied a miniscule portion of the KSJO(FM) and WRBJ-FM service areas, and what will be the impact of ZoneCasting on listeners travelling away from the primary signal on the far side of a booster?[58]

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[55] WRBJ-FM Test Report at 20.

[56] GBS has tried to compare ZoneCasting's alleged consumer benefits with those allowed by the geo-targeting of programming by cable TV or potentially ATSC 3.0. Comments of GBS at 3, MB Docket Nos. 20-401 and 17-105, and RM-11854 (Feb. 10, 2021). These services are completely inapposite. Unlike radio listeners, most viewers of these services are stationary, and the service they receive is static. Viewers do not experience any disruption caused by the transition of content delivery from one transmission system to another. They may receive programming from one or the other, but never both at the same time. To the extent that Distributed Transmission Systems may be used in ATSC 3.0, handoffs between transmitting nodes are seamless due to the inherent design of the system, which uses Orthogonal Frequency-Division Multiplexing (OFDM) rather than FM modulation. OFDM encodes data on multiple carrier frequencies, allowing it to cope with severe interference, including self-interference between multiple transmitting sites. This is not possible with FM, which is a single carrier system. On the other hand, most radio listening occurs while people are driving, meaning that listeners will be exposed to ZoneCasting's disruption as their radio reception bounces from the primary signal to a booster with different content. Unlike TV viewers at home, the interference imposed by ZoneCasting will be unavoidable and likely take listeners by surprise.

[57] NPRM, 35 FCC Rcd at 14217.

[58] Beasley et al. Comments at 15-16

All of these efforts to manufacture the best results render both the KSJO(FM) and WRBJ-FM tests useless, and certainly not worthy of an expert agency's reliance to advance GBS's proposal. We further note that GBS's testing to date pales in comparison to that normally conducted or required before a new technology is authorized, such as all-digital AM, hybrid (analog plus digital) HD Radio, or digital television. Nevertheless, even this insufficient amount of analysis demonstrates that "the magnitude of potential interference to the primary (host) FM station is great and largely unavoidable," and "that ZoneCasting™ cannot compensate sufficiently for its harm and therefore is broadly unsuitable for FM radio broadcasting."[59]

If the public's interest is driving this proceeding (i.e., listeners), then the Commission's conclusion should be very straightforward. There is simply no way GBS has met its burden to demonstrate that its service will not cause harm, even if the Commission considered only GBS's cherry-picked results. And the notion that somehow this matters less because the proposal only seeks to authorize and not require using GBS's technology is misplaced. It will be of little solace to consumers who lose clear radio service for ten or 25 or even more seconds as they travel through an area where their favorite station's signal bounces from the primary station to a booster and then possibly back to the primary station or another booster. Most listeners will quickly become confused and annoyed, and question whether the problem stems from the station, FM radio service, or their car. The Commission should not permit such an outcome, and definitely not do so based on the flimsy, misleading, and inaccurate technical data provided by GBS.

[59] ZoneCasting Tests Analysis at 16.

IV. CONCLUSION

For the reasons stated above, NAB submits that the costs to consumers of allowing ZoneCasting far outweigh the hypothetical benefits suggested by GBS. Accordingly, we respectfully ask the Commission to dismiss GBS's proposed rule change that would authorize program origination using boosters.

Respectfully submitted,

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June 6, 2022

Analysis of Technical Reports for ZoneCasting at KSJO(FM), San Jose, CA and WRBJ-FM, Brandon, MS

Prepared for
National Association of Broadcasters
and National Public Radio

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Introduction

This document was prepared as an independent analysis of the technical reports of geo-targeted demonstration systems at FM Station KSJO, San Jose, California and Station WRBJ-FM, Brendan, Mississippi, employing "ZoneCasting™" technology.

Summary

Two field trials were performed of an on-channel booster technology called "ZoneCasting™" (ZoneCasting or ZoneCast) by the proponent, GeoBroadcast Solutions ("GBS"), allowing FM stations to "geo-target" certain portions of their authorized service area with programming that differs from the primary transmitting facility. GBS hired the firm of Roberson and Associates, LLC to conduct field trials and prepare technical reports. Through the GBS attorneys on September 17, 2021, a technical report on a field trial for KSJO(FM) was filed in response to the Commission's NPRM on FM booster stations.[1] A technical report on another field trial for WRBJ-FM was filed on March 30, 2022. As described herein, the reports contain fundamental technical issues, including incomplete and contradictory data. It is also shown that the field trials used flawed methodology and provide only partial results that do not provide a complete and accurate picture of the performance of ZoneCasting and its potential undesirable effects on station reception by listeners. Most importantly, it is shown that ZoneCasting is generally unsuitable for FM broadcasting because it can produce areas of substantial and irreparable signal interference to the host station that listeners would consider unacceptable.

Technical Basis for Signal Interference Caused by ZoneCasting

FM broadcasting is a medium that radio listeners know to be reliable and deliver high quality sound. The recent growth of digital audio for streaming and content playback has given listeners a new

[1] Notice of Proposed Rulemaking in the Matter of Amendment of Section 74.1231(i) of the Commission's Rules on FM Broadcast Booster Stations, MB Docket No. 20-401, RM-11854; Modernization of Media Initiative, MB Docket No. 17-105, Adopted November 20, 2020.

reference for audio that is almost totally free of noise and interference. As a result, broadcasters and regulators should be cautious in adopting any technology changes that may degrade the perceived quality of FM radio signals. As demonstrated herein, ZoneCasting produces a form of co-channel interference that may introduce substantial degradation to a host station's audio quality.

Results of Listener Tests. ZoneCasting and the related simulcast single-frequency network (SFN) booster signal reinforcement technology (what GBS terms "MaxxCasting") were studied at NPR Labs more than a decade ago.[2] Based on NPR Labs' experience in this field, GBS engaged NPR Labs in 2012 and 2013 to produce comprehensive design criteria for both technologies.[3] Because both ZoneCasting and SFNs have the potential for interfering with the host station's primary (*i.e.*, full-service) signal, design parameters are needed to balance the potential effectiveness of a booster network against potential degradation to the host station's reception. Interference to FM reception as evidenced by degraded audio quality is a perceptual phenomenon that requires controlled listener testing to assess. The results of this testing are used to derive the design parameters. The NPR Labs work done for GBS developed test protocols by a perceptual psychologist with extensive experience in listener testing and the test system was implemented by the undersigned.

Testing involved dozens of adult listeners who were screened for hearing impairments. This number of participants was needed to ensure statistical significance of the results. A total of 622 audio test samples were collected and evaluated for the ZoneCasting technology alone (the samples were of various levels of co-channel interference) in addition to those for conventional SFN conditions.[4] The audio samples were derived from carefully selected music, speech and speech-over-music segments.

The audio samples used in these controlled tests were simulated stereo FM transmissions that were received using actual automotive receivers. To simulate realistic mobile reception conditions an RF channel simulator was used to create Rayleigh fading on the primary FM signal. The ZoneCasting

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2 NPR Labs was the research and development office of National Public Radio, at its Washington DC Headquarters. It conducted contract research projects on technology of potential benefit to the public radio system. Research data remains the property of National Public Radio, which is a commenter in this proceeding. The ZoneCasting study results obtained from the NPR Labs listening tests have not been publicly disclosed until now.

3 The SFN results were published in the Proceedings of the 2013 NAB Broadcast Engineering Conference, *Design Parameters for Analog FM Signal Repeaters Based on Listener Testing*.

4 Note that the principal difference between the ZoneCasting and SFN tests is that for ZoneCasting the booster signal is a different audio program than the main signal, while the SFN tests involved simulcasting of the main signal by the booster.

booster's FM signal passed through a separate channel simulator to generate Rician fading, which is more representative of signal propagation over smaller distances with a relatively clear direct path from the booster transmitter to the mobile receiver.

The ZoneCasting test required listeners to assign a "keep on" score[5] as well as a Mean Opinion Score (MOS) on a five-point ITU scale (1-bad, 2-poor, 3-fair, 4-good, 5-excellent). Based on the 20 dB desired-to-undesired (D/U) signal ratio commonly used in the FCC's co-channel FM allocation rules, four D/U values were evaluated by the listeners: 0 dB, 5 dB, 11 dB and 18 dB.

The combined listener response to ZoneCasting interference was surprisingly critical. As the chart in Figure 1 shows, fewer than 27 percent of listeners indicated that they would keep their radio tuned to the station at the highest D/U signal ratio of 18 dB. This result suggests that even the FCC's co-channel protection ratio is marginally adequate to avoid listener tune-out. The listeners' MOS at 18 dB was poor-to-fair at 2.48 for those who would keep the radio on (continue listening) and poor (2.02) overall. The high anchor reference,[6] having only a small amount of noise and distortion, is included to show the listener's MOS score of 4.41. This produced a 100 percent keep-on score.

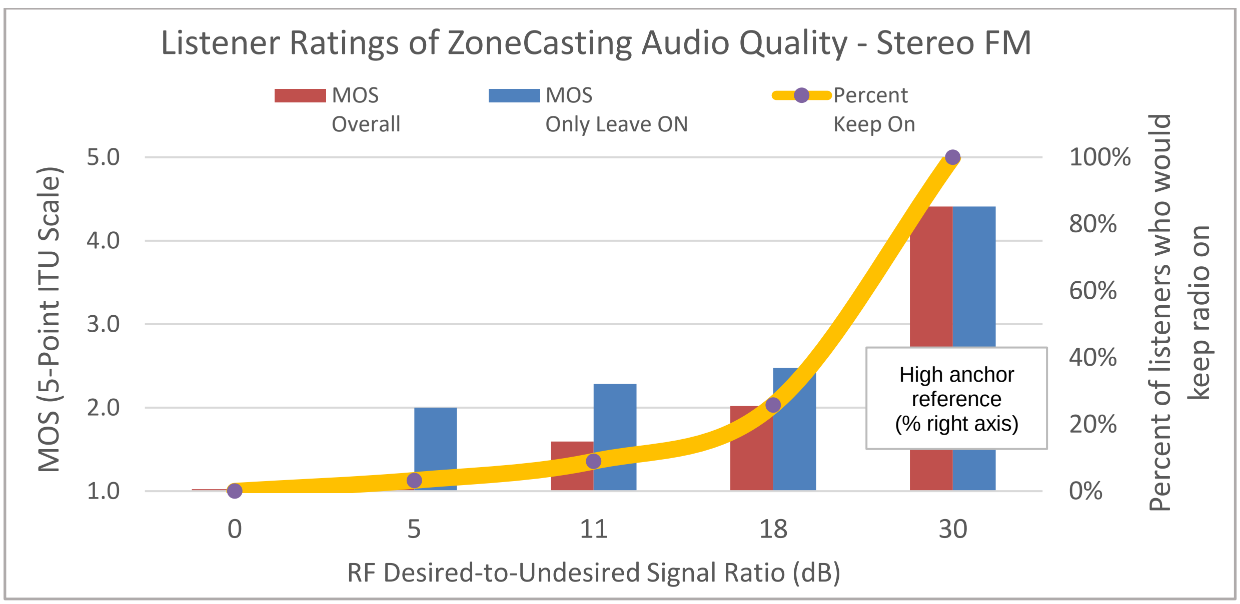

Figure 1. Listener ratings of ZoneCasting audio quality (stereo FM).

5 A "keep on" score represents whether or not a listener would continue listening to the station or tune away from it.
6 The "anchor reference" is the MOS for the undegraded audio. A reference of less than 5 (excellent) is not unexpected. Often, people are reluctant to assign a perfect rating, assuming that there must always be room for improvement.

The results of the ZoneCasting response prompted further study. After the testing, interviews with some of the participants revealed that the intermittent "break-in" of the primary audio by different content from the ZoneCasting signal was far more annoying than equal-level bursts of neutral noise and distortion in the audio. That explained why this type of interference received such unfavorable scores, when it was first thought that 18 dB would be a tolerable D/U ratio. The D/U scores from the primary transmitter and a ZoneCasting booster are effectively reversible, so the same ratio can be applied to both the inner and outer boundary of the ZoneCasting region. A full derivation of the interference ratio for ZoneCasting Interference is presented in Appendix 1 and Appendix 2.

Interference Criterion. Based on the foregoing listener test data and application of signal statistics, the WRBJ-FM interference maps shown later in this report apply a generous 11 dB ratio to define interference, rather than the 20 dB used by the FCC for co-channel protection or 18 dB (27 percent keep-on with ZoneCasting) in the NPR Labs study. Two caveats should be noted in estimating ZoneCasting interference:

- Listeners may be highly annoyed at a calculated 10 percent probability factor (or even less)
- Car radios typically receive in stereo, which is much more susceptible to interference than monophonic FM. However, car radios employ stereo blending at low signal levels and other noise mitigation features to help improve listener keep-on. Thus, for this study it is conservatively assumed that the car radios operate more like monophonic FM receivers than stereo ones. This may not be the case for fixed receivers, however, which lack noise mitigation features and would be substantially more susceptible to ZoneCasting interference.

Considering these caveats, the predicted interference areas shown in the following maps could be considered by listeners to be much worse (larger) than what is shown.

Analysis of KSJO(FM) Technical Report

FM Station KSJO is a Class B facility operating on channel 222 (92.3 MHz) operating from Coyote Peak, located at the southern end of the Santa Clara Valley, approximately four miles from San Jose. The valley is near sea level and is surrounded by hills and mountains. The color underlay in Figure 3 is the predicted field strength of KSJO's primary transmitter using the Irregular Terrain Model (ITM, also known as "Longley-Rice"), which shows, that terrain tends to contain KSJO's primary signal within the valley and reduces effective service in outlying areas within the station's 54 dBμ service contour. For this reason, KSJO operates booster FM1, which helps to cover the communities of Dublin, Pleasanton and Livermore, which are obstructed by terrain from the KSJO main transmitting site.[7]

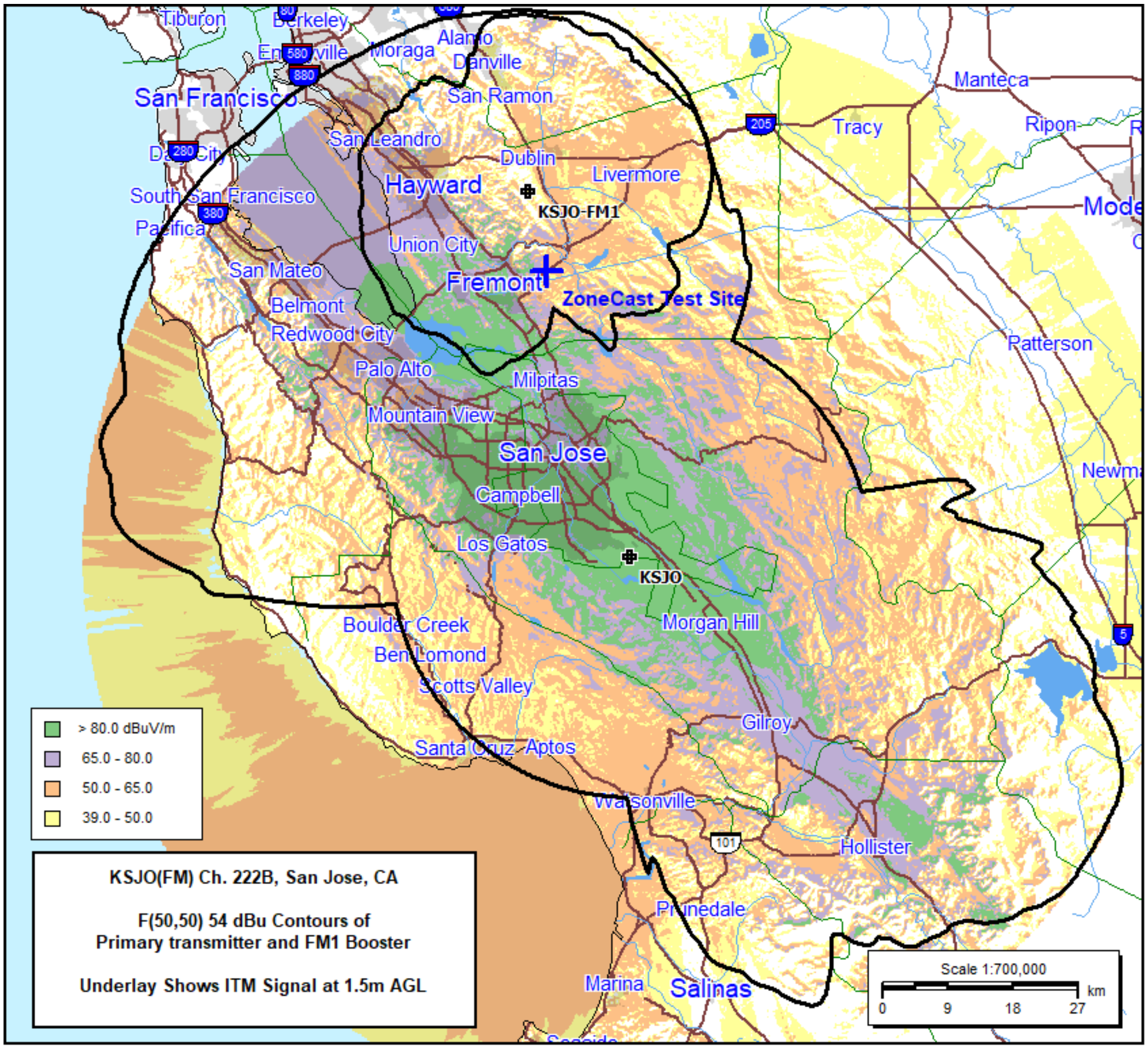

Figure 2 - KSJO(FM) ITM terrain-sensitive coverage at 1.5m AGL, with 54 dBμ service contour of primary FM and FM1 booster. Location of ZoneCast test is shown with blue crosshairs.

Figure 2 also shows the location of the only test site used for determination of the "Zone Transition Region." This site is located east of Fremont on an elevated ridgeline separating the Santa

7 KSJO requested a modification of booster FM1 in connection with its experimental operation "to extend and enhance the test by adding additional antennas." See Request for Extension of Experimental Authorization and Waiver, File No. 20210727AAG, granted 8/31/2021. However, it is unclear whether the change to FM1 was made, and Roberson does not mention the FM1 booster in its report, passing up an opportunity to test ZoneCasting over a large geographic area.

Clara Valley and Bay Area from the inland valley of Pleasanton and Livermore. The location was identified in KSJO's experimental request[8] as "I-680, Sheridan Site 1" but later referred to as "FM3 FM2 Booster" in the KSJO Report.[9]

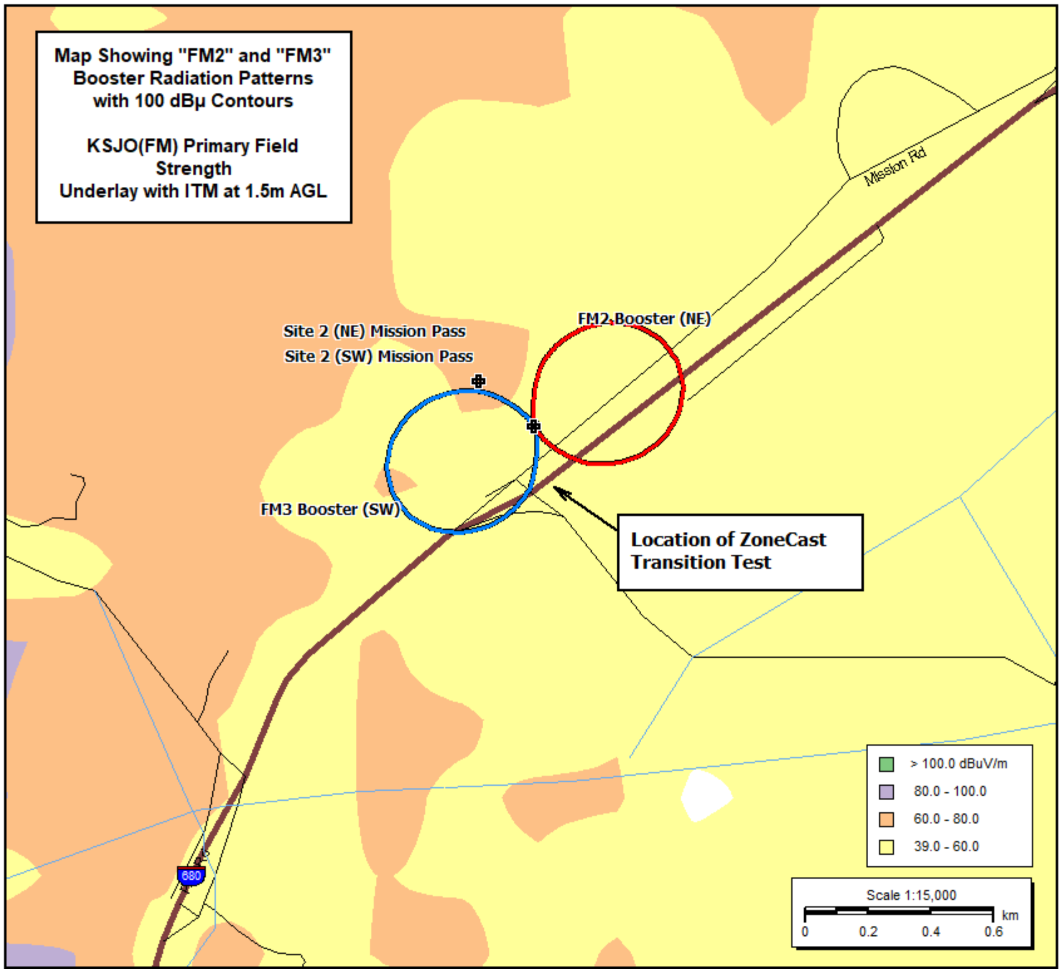

Figure 3 - Small scale view of the "FM2" and "FM3" booster site used in the KSJO field test.

A close-in view of the "FM3 FM2 Booster" test area, which is about 100 meters from Interstate 680, is shown in Figure 3. The two boosters are described in the KSJO Report as "Back-to-Back, High Front-to-Back Ratio Antennas" on a telescoping mast. The 100 dBµ field strength contours of the two boosters, shown with blue and red lines, illustrate the high directivity of these antennas. The color

[8] Letter from Miles S. Mason to Marlene H. Dortch, Request for Experimental Authorization and Waiver of 47 CFR 74.1231(i), February 3, 2021 ("KSJO experimental request")

[9] KSJO Demonstration System, Geo-targeted FM/HD Broadcast Technical Report, Roberson and Associates, LLC, 17 September 2021 (KSJO Report).

underlay in Figure 3 is the field strength of KSJO's primary transmitter using the Irregular Terrain Model (ITM, also known as "Longley-Rice") at a height of 1.5 meters above ground. Predicted field strengths along the roadway are between 39 dBµ and 60 dBµ; thus, KSJO's primary signal was insignificant compared with the booster signals. The KSJO experimental request notes that "the locations were selected for the experimental zone border because there is no coverage by either KSJO(FM) or KSJO-FM1 in the southern portion of the pass."[10]

The proximity of this site to the Interstate 680 test route has a large effect on the test results. Figure 4 shows a capture of Figure 12 from the KSJO Report as an aerial view with the test paths marked in aqua. The path end points in the measured "Zone Transition Region" are indicated by green and red dots.

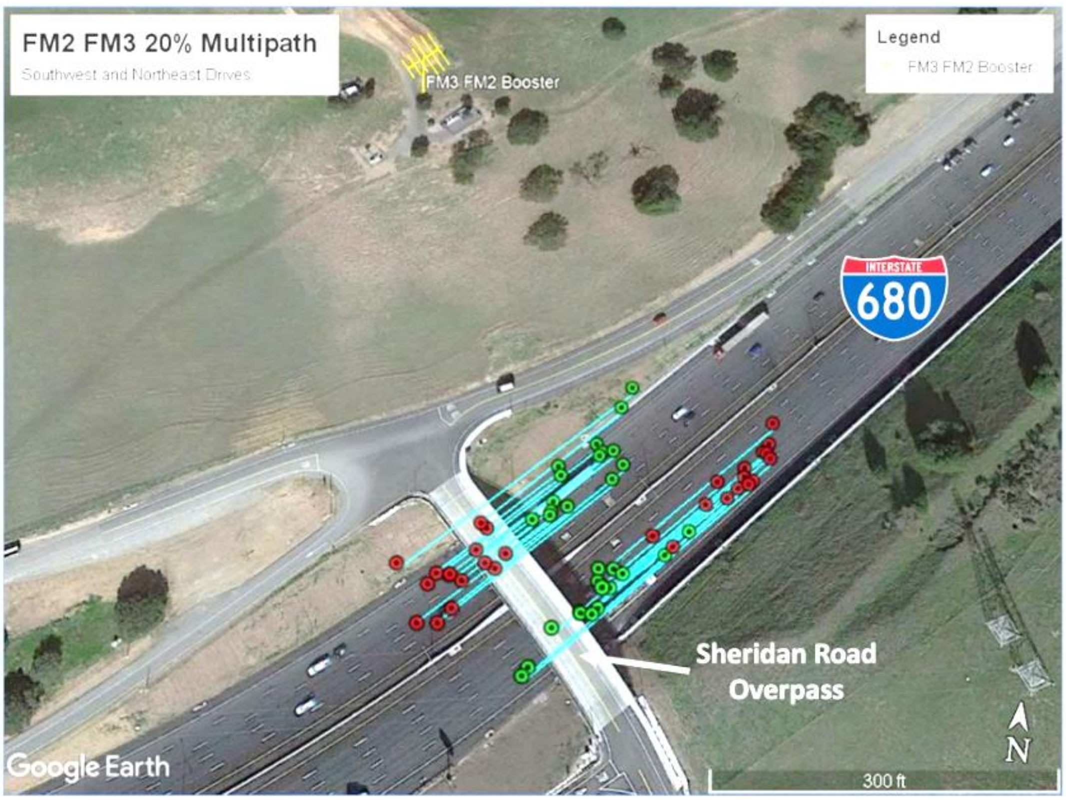

Figure 4 - Capture of Figure 12 used in Roberson KSJO report showing booster site and roadway where "Zone Transition Region" was measured.

It is apparent that the "Zone Transition Region" in the KSJO Report simply coincides with the minima between the booster signals (area between the blue and red contours) shown in Figure 3. Many

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10 KSJO experimental request, *op cit*.

of the measurements run below an overpass that can influence signal propagation. Data taken here are not representative of what would be obtained using a ZoneCasting system based upon a full-service FM signal interacting with an FM booster signal that establishes the zone, *i.e*., the baseline ZoneCasting architecture. The zone transition in this case is simply a demonstration of the *handoff* behavior between "Back-to-Back, High Front-to-Back Ratio Antennas," nothing more.

The authors of the KSJO Report appear to take no effort to measure and evaluate signal conditions with the two boosters at more distant locations where emissions from the two boosters and the primary signal overlap. Indeed, this ZoneCast booster location is isolated, providing measurement data applicable only to a small portion of the Interstate highway.

A second, higher booster site called "I-680, Mission Pass Site 2" was also requested by KSJO, as shown in Figure 3. Its greater elevation and distance from the highway would have substantially increased the size of the so-called "Transition Region" along the highway and would have provided a better representation of the performance of the ZoneCasting system. This and the even larger FM1 booster site were authorized[11] for experimental ZoneCast testing, but are never mentioned in the KSJO Report, despite the Media Bureau's routine requirement for a "full report" of authorized experimental facilities.

The "Zone Transition Region" test of boosters FM2 and FM3 was the only test included in the KSJO Report. The isolated location and limited transition zone size make that test of little predictive value elsewhere. Due to the lack of comprehensive test results, no further analysis of interference is performed for the KSJO study.

Analysis of WRBJ-FM Technical Report

WRBJ-FM, Channel 249A is licensed to Brandon, Mississippi and is located in a rural area approximately equidistant from the towns of Brandon, Florence, Mendenhall and Pelahatchie. As Figure 5 shows, the station's 60 dBμ service contour covers a portion of the City of Jackson, the state capital. The gray shading shows the populous areas of Jackson and other towns.

[11] Letter from Miles S. Mason to Marlene H. Dortch, Request for Extension of Experiment Authorization and Waiver of 47 CFR 74.1231(i), July 27, 2021 ("KSJO additional request")

The (50,50) 60 dBμ contours of the ZoneCasting booster facilities were projected using standard techniques from the data in the WRBJ Report.[12] As shown in Figure 6, it is apparent that the 60 dBμ contours of some boosters extend well outside the service contour of WRBJ-FM. Such contour extension would be in violation of §74.1201(h) of the rules, which prohibit any extension of the service contour of the primary transmitter. While WRBJ-FM may have initially engineered the boosters to be in compliance with the rules, the contours shown in Figure 6 represent the calculated distances based on data in the WRBJ Report, which is assumed to represent the actual operating facilities tested. These discrepancies are discussed more fully in the Conclusions section.

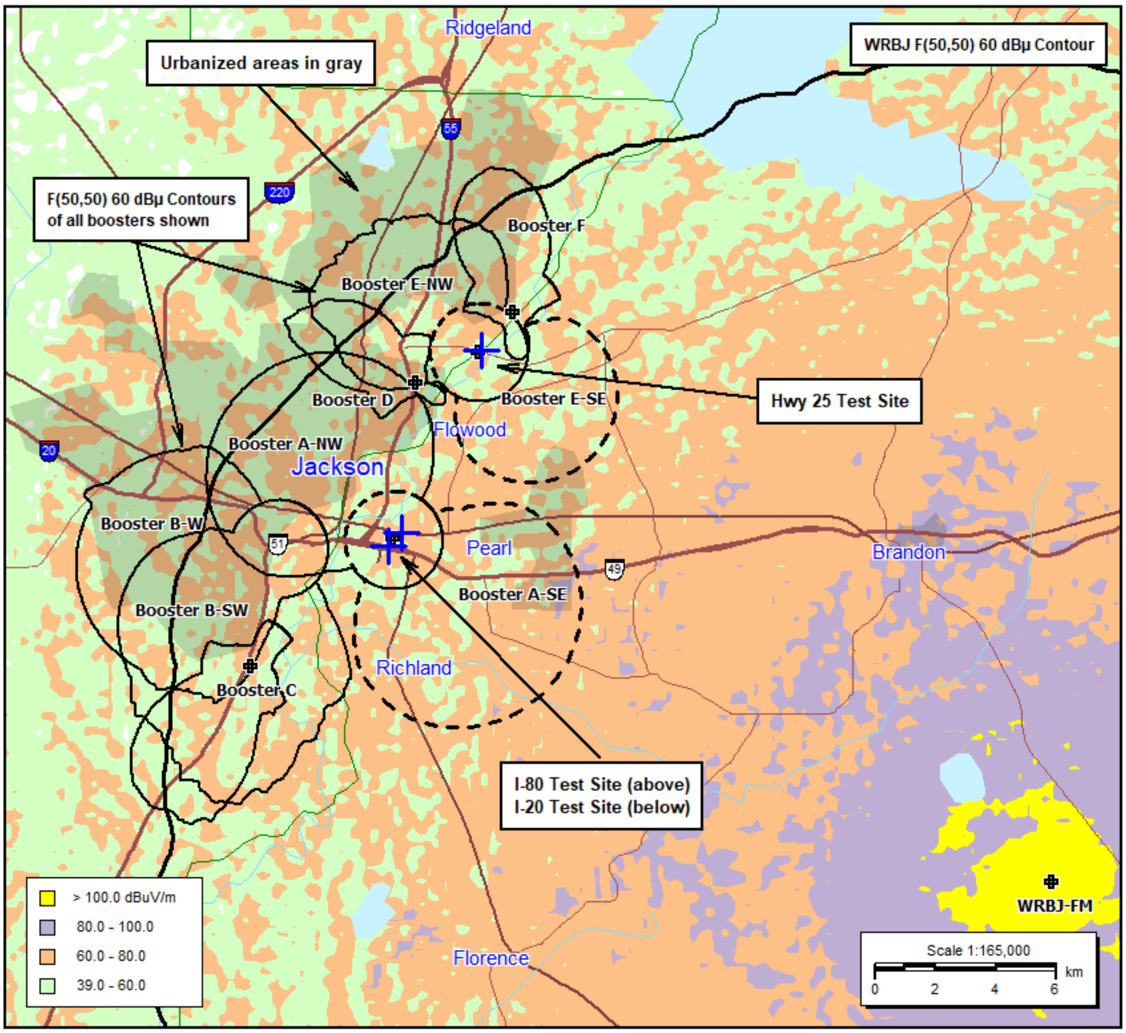

Figure 5 - ITM signal coverage of WRBJ-FM at 1.5 5m AGL with 60 dBμ contours of primary and booster.

12 WRBJ Demonstration System, Geo-targeted FM/HD Broadcast Technical Report, Roberson and Associates, LLC, 30 March 2022 (WRBJ Report).

Due to the relatively smooth terrain in central Mississippi, FM signals propagate farther than the FCC service contour would indicate. The WRBJ Report uses a minimum field strength of 39 dBµ "for monophonic FM."[13] For this study, the same 39 dBµ minimum field strength was used. Figure 6 and all other maps herein use the Irregular Terrain Model, Broadcast Mode, at 1.5 meters above ground, to represent the height of car antennas. Median time and location values are used along with standard ground parameters and 3-arc second SRTM terrain data at 250m gridding resolution.

Figure 2 of the WRBJ Report shows coverage which extends considerably less distance compared to that predicted by ITM and ends abruptly at distances of 32 to 35 km, suggesting the propagation model used does not reflect actual terrain conditions. Based on the ITM prediction, 39 dBµ FM service to mobile receivers is, in fact, shown as usable at most locations in and around Jackson.

Figure 6 is a smaller scale map providing a clearer view of the boosters used in the ZoneCasting test. The map underlay shows the ITM-predicted coverage at 1.5m AGL provided by the booster network separately from the primary coverage of WRBJ's transmitter, without consideration for mutual interference between the boosters or with the primary transmitter signal. The boosters identified as A-SE and E-SE are shown with dashed contours. They operate full time with the primary audio service and are not in the ZoneCasting network service, thus their ITM coverage is not included with the ZoneCasting boosters.

[13] *Ibid*, Footnote 3. Not identified are the height of the field above ground, the propagation model used, or time and location variability criteria.

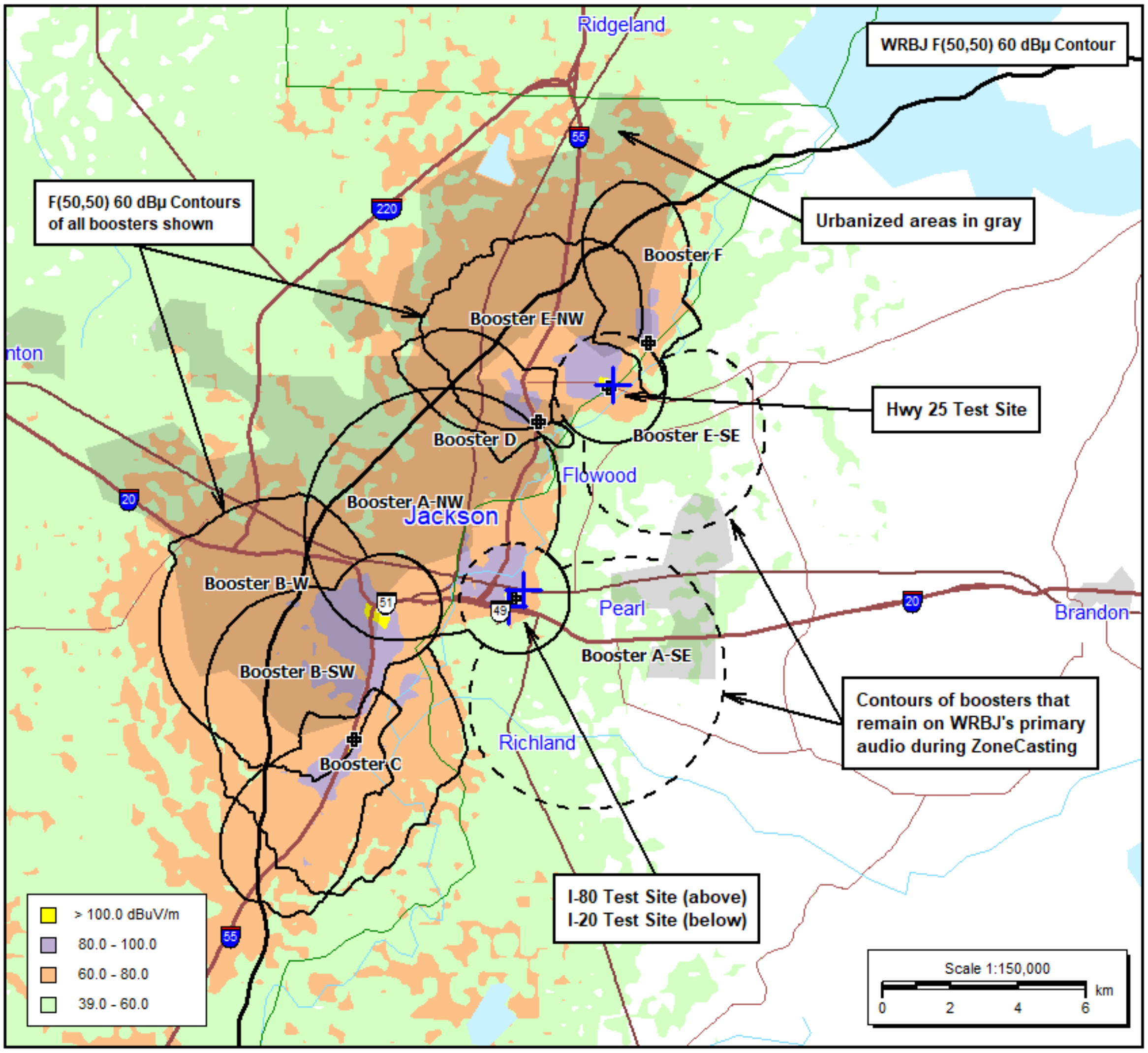

Figure 6 - ITM signal coverage of booster network only. During the ZoneCasting test, two boosters continued to carry WRBJ-FM primary audio. Three ZoneCasting transition test sites are marked with blue crosshairs.

Of particular interest are the locations of three test sites immediately adjacent to booster sites A and E. These are comprised of two pairs of highly directional transmitting antennas pointed southeast (toward the main transmitter) and transmitting a simulcast of the full-service signal, and northwest (and transmitting different content during ZoneCasting).

Figure 7 shows a small-scale map of the Highway 25 test location adjacent to Booster Site E. This is identical in arrangement to the "Zone Transition Region" site in the KSJO test discussed earlier, with booster pairs using highly-directional, back-to-back antennas. Again, orientations of the main beam of the antennas are located approximately parallel to the roadway, With this arrangement, and by only testing near these back-to-back booster installations, GBS is guaranteed to collect data showing the smallest possible transition area and with data that are also likely not reflective of anywhere else in the network.[14]

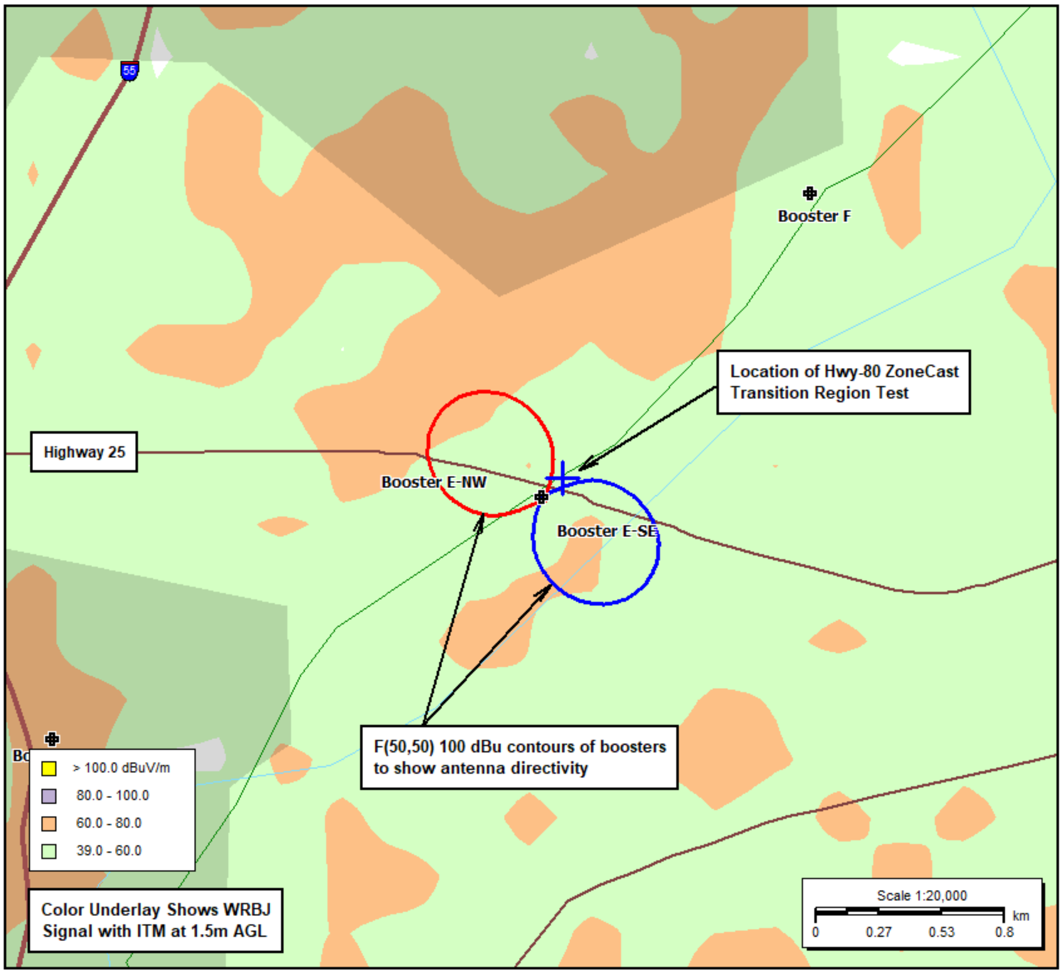

Figure 7 - Map of Hwy-25 ZoneCasting test area

The drive-by scenario is repeated for the Highway 80 and Interstate 20 test locations, shown in Figure 8. The sites share a common booster pair, A-NW and A-SE, which are rotated slightly (clockwise) in relation to the orientation of the roadways. As expected, the centers of both "Zone Transition Regions" are offset clockwise and remain at right angles to the antenna main beams.

[14] Note that as this scale small registration errors occur in roadway position. However, the location of the boosters and the drive route are determined exactly by their geographic coordinates, so the registration error in the road does not affect the relative site orientation.

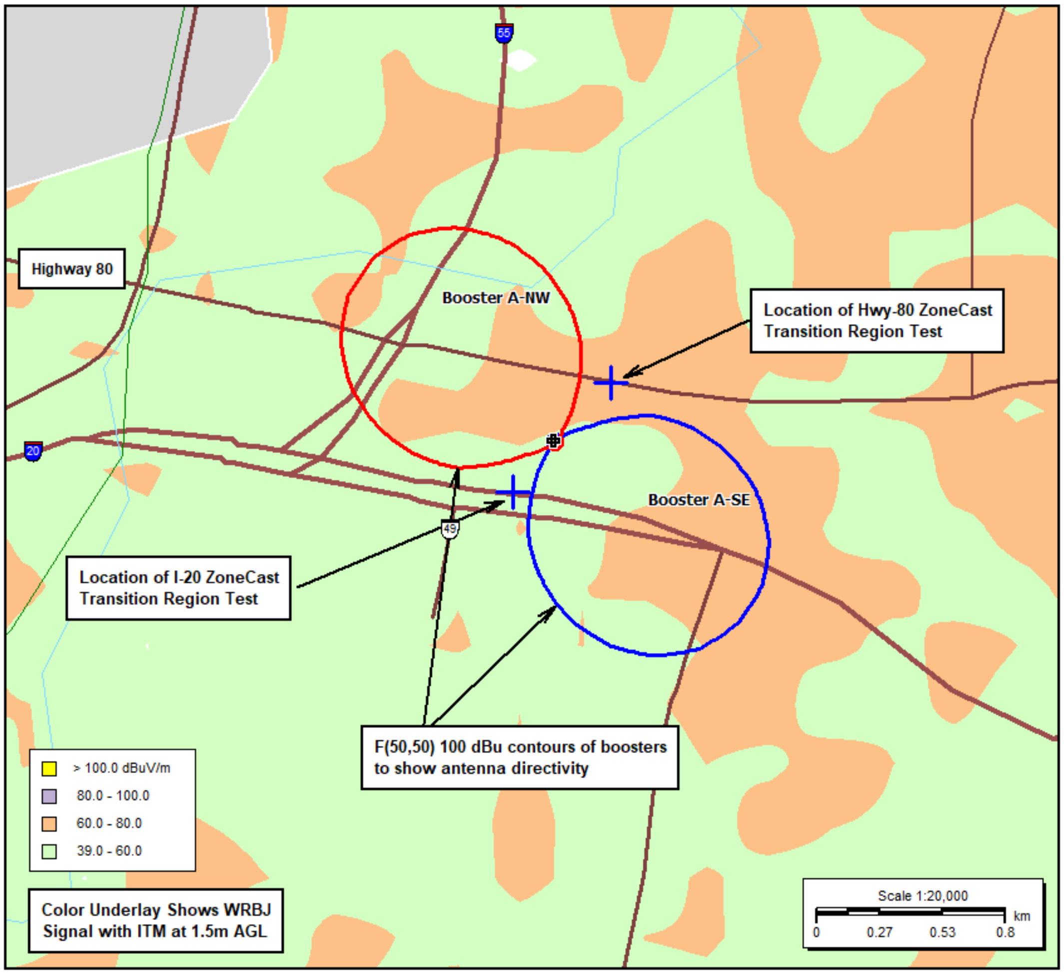

Figure 8 - Map of I-20 and Hwy-80 test areas

It is apparent that the booster configurations used strategically minimized the sizes of the "Zone Transition Regions" by placing the test sites at minimum distance from the boosters. Further, no testing was conducted in other areas of the ZoneCasting network, notably those areas that are too distant to benefit from the back-to-back antenna arrangement (which encompasses the vast majority of the zone).

Figure 9 depicts the predicted signal ratios between the ZoneCasting network and WRBJ-FM's primary signal. Using the 11 dB interference threshold to 10% of locations as derived in Appendix 1, the map shows significant areas of predicted interference – all in areas where no measurements were conducted.

Receive Condition	Color	D/U Ratio
Primary service	Green	>11 dB
Mutual interference	Red	11 dB to -11 dB
ZoneCasting service	Aqua	<-11 dB

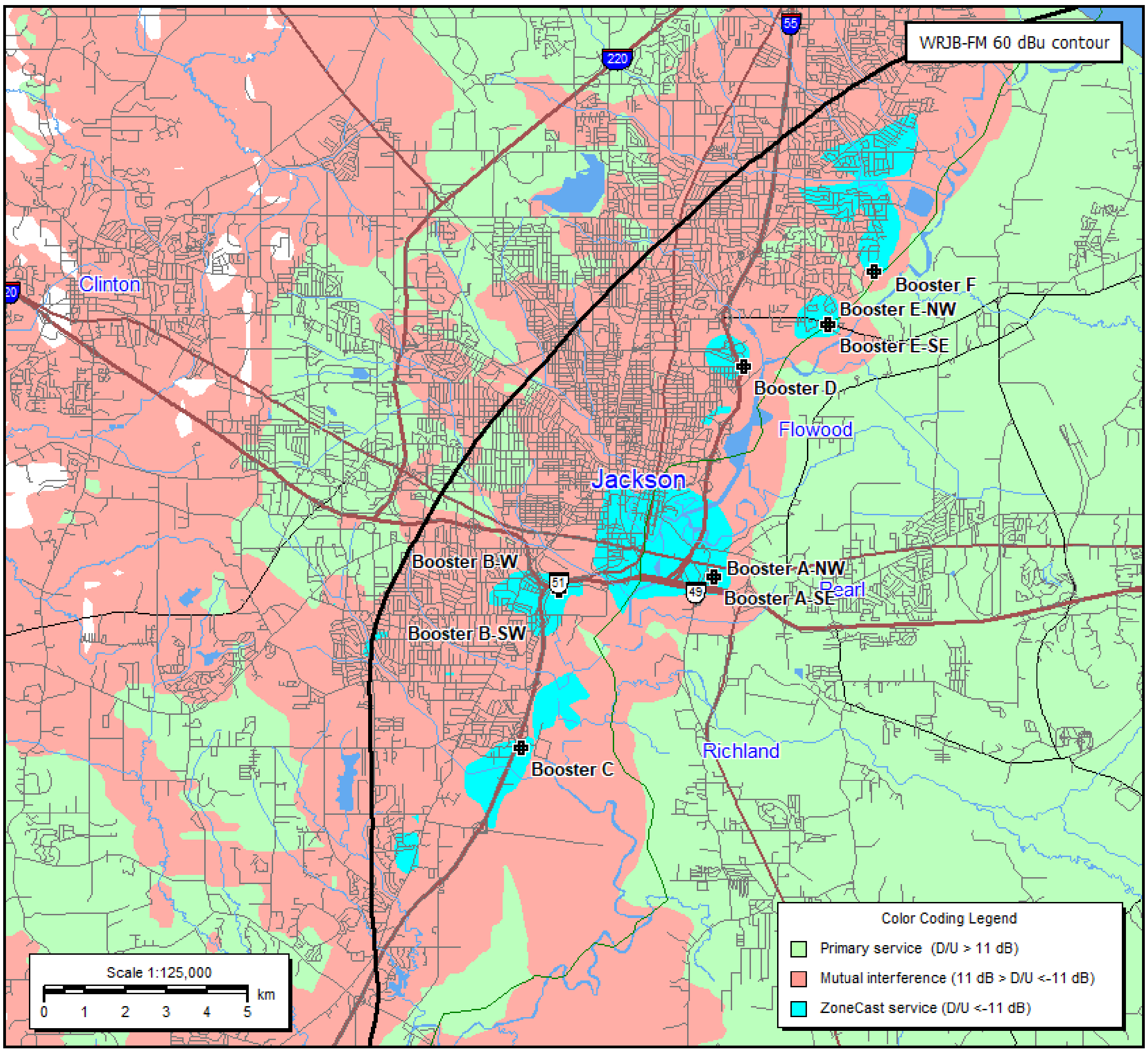

Figure 9 - Signal ratio map showing areas of predicted interference and service by the primary transmitter and ZoneCasting network

Mutual interference extends to such a degree that listener-satisfactory ZoneCasting coverage is not contiguous, as shown by the red coloring between the boosters' service areas (shown in aqua). Boosters A-SE and E-SE are reported to operate with the primary station audio during ZoneCasting operation, thus they would not contribute to interference. Since this scenario is not supported by the V-Soft Probe5 mapping software used in this report, these boosters are not active in this network depiction. Testing confirmed that their absence would has almost no effect on the map.

Comparing Figure 9 to the predicted primary coverage areas of WRBJ-FM before the addition of the ZoneCasting network, shown in Figure 5, it is clear that when ZoneCasting is in operation a substantial portion of Jackson could experience reception quality that listeners deem as "poor" and worthy of "turn-off" by 91 percent of listeners, according to the NPR Labs study data. This impact occurs both inside of WRBJ's service contour as well as in populous areas outside the contour where the primary signal is predicted to be usable by mobile receivers.

Conclusions

There are a number of flaws with the methodology used in both the KSJO Report and the WRBJ Report and the characterization of the reported results. In view of the objective information provided herein, the magnitude of potential interference to the primary (host) FM station is large and largely unavoidable. Consequently, it is the undersigned's conclusion that ZoneCasting cannot compensate sufficiently for its harm and therefore is broadly unsuitable for FM radio broadcasting. The specific flaws are described below.

Misrepresentation of transition areas. One of the most egregious issues is the depiction of interference regions between the primary and ZoneCasting booster: the KSJO and WRBJ Reports illustrate the interference, euphemistically called the "Zone Transition Region" as a thin band that appears around the perimeter of the Zone Coverage Area as shown in Figure 11. The illustration shown in Figure 11, which is included in both technical reports, appears to associate the band's cross-sectional size with the tiny handoff area where measurements were taken. These are deceptive and inaccurate showings since the measurements taken show only back-to-back booster handoff, not the extent of interference. That the report authors misunderstand the nature of ZoneCasting interference is illustrated in Section 4.1.5 (page 36) of the WRBJ-FM Report:

> "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…"
>
> "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…"

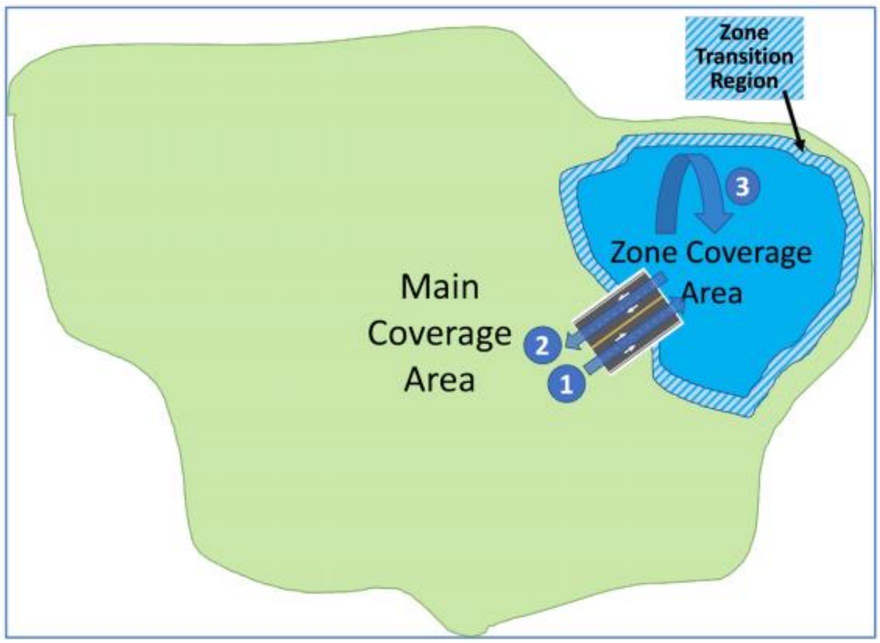

Figure 10 - Capture of Fig 4 from WRBJ Report showing size of "Zone Transition Region"

Misrepresentation of percentage of roads affected by ZoneCasting interference. The report authors compare its measurement of "mean zone transition length" (50.2 meters in the KSJO Report) with the total length of all roads in the Pleasanton (CA) area, comprising 621,000 meters of roadway.[15] In the WRBJ Report the same type of measurement in a small (73.9 meters) "transition zone" is compared with the 386,100 meters of roads in area, claiming that "only 0.11%" of roads will be affected. Claiming the size of the unique handoff test distance to represent "general received signal behavior" in the area affected by the ZoneCasting signal is preposterous. Lacking proper methodology, only a gridded study of D/U ratio-based interference would be acceptable.

[15] KSJO Technical Report, pg. 36.

The areas of interference shown in Figure 9 were determined using V-Soft Probe5, a widely-used engineering software tool, which calculates terrain-sensitive, grid-based D/U signal ratios as applied in numerous studies for the FCC. (The FCC also uses this software for certain studies.) Using the engineering specifications provided in the WRBJ Report, a receive height of 1.5 meters above ground was used. The resulting map shows that the ZoneCasting booster network pervades the primary service area of WRBJ-FM with interference. Their claim that interference occurs only the "transition region" and falls in "unpopulated areas" is wholly unsupported and inaccurate. For all of Roberson's efforts to show signal handoff next to back-to-back boosters, they provide no serious map of measured or predicted interference – only the abstract map of Figure 10. The data and mapping provided herein show entirely different and unacceptable interference condition with ZoneCasting.

Fundamental lack of understanding of multipath measurements used to assess transition areas. The report authors use an automatic instrument to report audio interference as the test vehicle drives through the zone handoff region. However, their report acknowledges that the instrument is designed for multipath interference indication.[16] In a misunderstanding of the instrument's operation, they state that multipath reception, which is indeed a "time-delayed" combination of the direct and reflected signals, is equivalent to the "two signals" transmitted by the primary and ZoneCasting transmitters: that is, multipath involves duplicates of signals that are different by only microseconds of time, which in simple terms causes FM detectors to distort the audio. They do not appear to realize that ZoneCasting involves an entirely different version of program audio from the host station's primary signal, which is properly called co-channel interference – not "multipath."

The instrument used by Roberson is designed around ITU-T Recommendation P.863, a telephony standard which is "a means of estimating listening speech quality by using reference and degraded speech samples" lasting between 3 and 6 seconds.[17] P.863 was developed for assessing quality of telephone networks. Table 9 of P.863 lists a number of "Factors not validated" with the algorithm described, including "Multiple simultaneous talkers," "Music as input to a codec" and "Listener echo." All of these factors are applicable to ZoneCasting and these exceptions are obviously concerning when attempting to measure artifacts in speech and music transmitted over FM signals experiencing co-

[16] WRBJ Report, p. 24
[17] Recommendation P.863.1 (06/19), https://www.itu.int/rec/T-REC-P.863.1-201906-I/en

channel interference, causing hard switching (FM capture) between the primary and ZoneCasting audio, music programming and random noise bursts.

Roberson claims that the P.863 method is a "reliable and useful" indicator of "geo-targeted broadcast transition events" but provides no objective data that correlates real listener testing of ZoneCasting interference with the algorithm. The presence of data from controlled listener tests at NPR Labs, which GBS received in 2013, should supersede any automated device designed for testing telephone circuit quality. Of course, the NPR Labs data indicates that ZoneCasting interference is strongly disliked by human listeners.

Misrepresentation of use of NPR Labs data on ZoneCasting network design. GBS has cited the NPR Labs perceptual testing in its advertising literature, industry presentations and interviews.[18] In GBS' original Petition for Rulemaking to the FCC, it said:

> "In 2013, Geo contracted NPR labs and Dr. Ellyn Sheffield of Towson University to conduct subjective listening tests in much the same way that HD Radio proponents tested that technology with Dr. Sheffield prior to approval of HD Radio by the FCC. Lab simulations of MaxxCasting and ZoneCasting configurations were set up and 19,000 audio samples were evaluated by over eighty listeners. Design standards for acceptable interference thresholds were developed and for the first time provided objective and verifiable interference targets which could be used in the design of booster systems, both with the same and different program content."[19]

Despite GBS' references to NPR Labs research in marketing and FCC comments, the authors of the KSJO and WRBJ Reports did not rely on the NPR Labs interference criteria for ZoneCast network operation and testing. Indeed, no field tests were conducted across Jackson to support the claim with "high confidence that ZoneCasting will provide minimal impact on the user."[20]

Inconsistencies in ZoneCasting booster site data filed with the FCC. It was noted earlier that inconsistencies in the ZoneCasting booster site data available from FCC records made it difficult to verify the network design and test the reported performance claims. This was true of both site data and antennas used, particularly for the WRBJ-FM booster network, as detailed in Appendix 3. Technical facilities data were given in only two documents at the FCC:

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18 GeoBroadcast Solutions blog, https://www.geobroadcastsolutions.com/castings/giving-boosters-their-best-shot, checked May 30, 2022.

19 See Appendix C, page 5, *In the Matter of Amendment of Section 74.1231(i) of the Commission's Rules on FM Broadcast Booster Stations*, RM-11854, GeoBroadcast Systems, March 13, 2020.

20 WRBJ Technical Report, pg. 40.

- File No. 20210604AAQ, a request for experimental facilities dated May 27, 2021
- File No. 20211129AAN, a request for extension and minor modification

These two requests list eight boosters in total, FM1 through FM8. However, the WRBJ Report lists boosters by names such as "Derrick" and "RiverSide," which are listed in Appendix 3. This inconsistency required an orderly naming to be set up, such as "A-SE" (meaning booster A, with a southeast antenna orientation). These are listed in the "Name Mod." Column.

Examination of the geographic coordinates found that only one of the boosters in the WRBJ Report was requested and authorized by the FCC: FM5. All of the other boosters have different coordinates, power, antenna height, type or orientation. It is unclear whether or not the boosters in the WRBJ Report were actually authorized, but documentation could not be found in FCC records.

No antenna specifications were provided in the WRBJ Report. There are tables giving cryptic names such as "Single log/dual log composite pattern" and that some antennas may be Jampro JAVA off-the-shelf models but no gain and relative field pattern data is provided for installations with special antenna rotation and stacking, where applied. Finding matches to the original engineering requests is particularly challenging because most of the antennas apparently used a slant linear polarization, which alters the horizontal-plane pattern data supplied by the manufacturer, and is dependent on factors such as vertical separation of two-bay arrays, which are not reported.

Considerable time was used to find and attempt a match to antennas in the engineering requests. Despite the lack of supplied antenna pattern data, the main beam power levels of many of the WRBJ-FM boosters result in maximum contour distances that do not match the maps in the Roberson report. The F(50,50) contour distance calculated at the specified beam-maximum ERP in the horizontal plane would be the same regardless of directionality of the antenna, which indicate errors in the report. Regardless of contour distance errors in the WRJB report, the magnitude of the errors is such that correction would have a minor effect on the results of studies for the booster network: the predicted interference to WRJB's service would remain almost unaffected from what is shown herein..

As a result of the missing or incomplete information, coverage predictions for the network were a 'best effort' exercise. However, as noted earlier, discrepancies in the antenna data would have a minor effect on the interference that was depicted for the WRBJ booster network during ZoneCasting operation.

Certification

This study of the ZoneCasting reports for KSJO(FM) and WRBJ-FM was prepared by the undersigned and is true and correct to the best of his knowledge and belief.

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June 6, 2022

Appendix 1

Behavior of Primary and Booster FM Signals in Mobile Receiver

Signal fading from the primary transmitter and booster are an unavoidable effect of signal propagation in the physical world. Reflections from the ground, structural clutter and terrain features form separate signal path lengths different from the direct signal path that may randomly reinforce, distort or cancel each other at the location of the listener's receiver. When a receiving antenna moves through space, as with mobile reception, signal fading occurs dynamically. The left side of Figure 11, below, shows the signal level variation over a one-minute period during a mobile measurement with time moving from left to right. It is apparent that FM signals vary widely and undergo sharp drops in level, along with occasional rounded peaks.

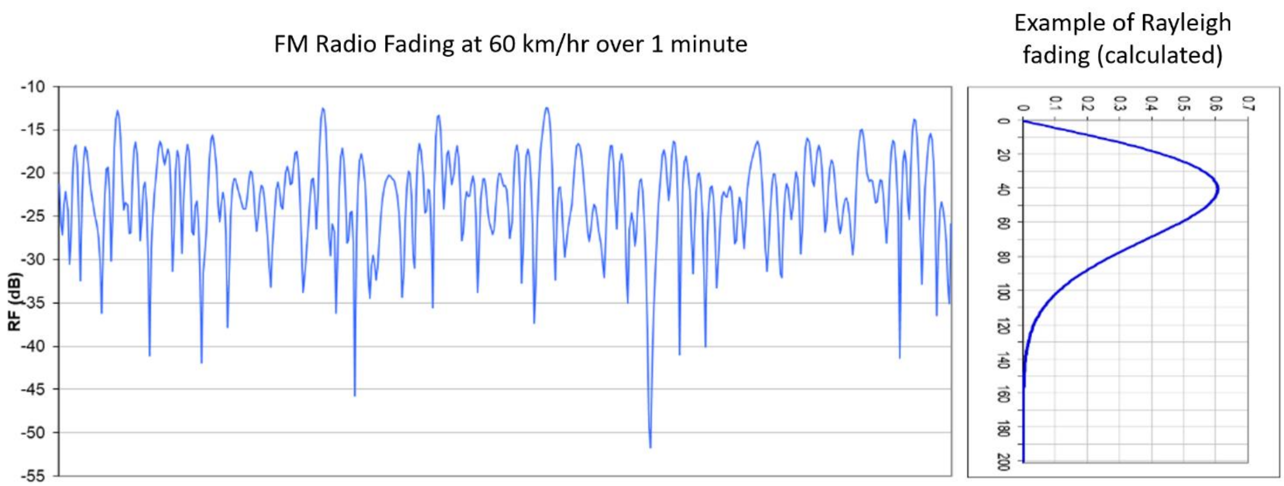

Figure 11. Signal variation over a one-minute period during a mobile measurement of FM radio.

Measurement data when normalized and represented as a probability distribution (showing the likelihood that a particular signal level is reached) assume a statistical distribution as similar to that shown on the right side of Figure 11. This plot of the distribution shows log-amplitude (normalized dB) versus probability of occurrence (1.0 would occur full-time) and its shape is characteristic of a Rayleigh distribution.[21] It can be seen that the most occurrences of the signal occur near the top (near the upper part of the measured signal) with the maximum likelihood approximately 20 dB below the maximum measured signal level. This distribution is asymmetrical, with the lower parts of the signal represented

21 A Rayleigh distribution occurs when a large number of vectors of random phase are combined. In this case, the vectors are the FM signals that reach the receiver through various propagation paths (reflections from clutter, terrain features, etc.)

by deep but less-frequent drops in signal level. Thus, when the desired FM signal drops sharply and there is another, co-channel FM signal present, signal replacement ("FM capture") occurs momentarily. That replacement is the same phenomenon that the listeners found most annoying in the NPR Labs tests of ZoneCasting.

The variability of FM signals in space (and time, when in motion) must be considered in estimating the occurrence of interference to service. When there are two signals originating at different transmitting sites (whether two different radio stations or an FM station and its ZoneCasting booster), the two signals propagate over separate paths, and produce two signals that fade independently of one another. Statistically, it can be said that the two signals combine with a joint probability at the receiver. Dealing with the mathematics of joint probability is complex but this phenomenon is addressed in the technical literature.[22] Appendix 2 derives a simple formula for converting jointly fading signals into a decrease in the protection between two independent signals.[23]

The amount by which a station's signal strength varies over some distance or time interval is described by the standard deviation of is signal strength probability distribution. When two stations (*e.g.*, a primary facility and a booster) are involved, the amount of variation is described by the standard deviation of the joint probability of their signal strength distributions. The standard deviation, σ_L, of field strength with respect to location is given as 8 to 12 dB in texts by Egli[24] and the ITU[25] (a lower value relating to populous areas and the higher to open environments). Applying the formula in Appendix 2 for an assumed standard deviation of 8 dB (2.51) for a 10 percent probability of interference, the desired-to-undesired signal strength ratio (F_d to F_u), R, is:

$$R = 0.1 \cdot \sqrt{2} \cdot 2.51 = 0.28 = -9.0dB$$

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22 Wong, Harry K., A Computer Program for Calculating Effective Interference to TV Service, Federal Communications Commission, OST Technical Memorandum FCC/OST TM 82-2, July 1982.

23 Kean, John, Report to the CPB and FCC on the Advanced IBOC Coverage and Compatibility Study, National Public Radio, NPR Labs, November 24, 2009, pp. 78-79.

24 Egli, John J., Radio Propagation Above 40 MC Over Irregular Terrain, Proceedings of the I.R.E., Vol. 45, No. 10, October, 1957, pp. 1383-91.

25 Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 4 000 MHz, Rec. ITU-R P.1546-6.

A good monophonic FM receiver can be expected to have a capture ratio of less than 2 dB, meaning the desired signal ("D") must be at least 2 dB stronger than the undesired ("U") to avoid co-channel interference. The above formula provides a reduction in interference discrimination; thus, the minimum required protection ratio as a result of joint independent fading is (9 + 2 =) 11 dB. It is assumed that a 10 percent probability results in a condition that correlates with the results of the listener study indicating a keep-on of 9 percent as acceptable. However, this is a low criterion that may need to satisfy a greater percentage of listeners, such as a ZoneCasting interference ratio closer to 18 dB.

Appendix 2

Joint Probability of Service and Interference [26]

Besides operation at lower average signal strengths than indoor reception, mobile reception has other differences from indoor listening. For one, received signals experience large fluctuations in magnitude as the location changes, referred to a Rayleigh fading (in cases where the propagation by line of sight is not dominant). This fluctuation occurs to both a desired and any interfering signals, and is usually uncorrelated due to the independent paths to the receiver. For a given percentage of time and other considerations, the probability of interference to reception can be determined as follows:[27]

Let

F_d= field strength of the desired signal, expressed in dB

F_u= field strength of the undesired signal, expressed in dB

F_s'= minimum value of the desired field strength level for acceptable service in the absence of interference for a given percentage of time

R = desired to undesired field strength ratio ($F_d - F_u$), in dB, at which threshold interference occurs.

Assuming that F_d and F_u are independent, normally distributed variables with medians and standard deviations of (F_{dm}, σ_L) and (F_{um}, σ_L) respectively, the joint probability density function is[28]

$$f(F_d, F_u) = \frac{1}{2\pi\sigma^2} = exp\left\{\frac{-1}{2}\left[\left(\frac{F_d - F_{dm}}{\sigma_L}\right)^2 + \left(\frac{F_u - F_{um}}{\sigma_L}\right)^2\right]\right\}$$

The probability of interference to service is

$$P(F_d \geq F_s'; F_u \geq F_d - R) = \int_{F_d = F'}^{\infty} \int_{F_u = F_d - R}^{\infty} \quad .$$

[26] Advanced IBOC Coverage and Compatibility Report, submitted by NPR to the FCC November 4, 2009, In the Matter of Digital Audio Broadcasting Systems and Their Impact on the Terrestrial Radio Broadcast Service, ORDER, MM Docket No. 99-325

[27] A Computer Program for Calculating Effective Interference to TV Service, by Harry K. Wong, FCC OET Technical Memorandum 82-2, July 1982.

[28] Distributions in Statistics: Continuous Multivariate Distributions, by Norman L. Johnson and Samuel Kotz; A Wiley Publication in Applied Statistics; John Wiley & Sons, Inc., 1972.

In the presence of an undesired signal, the probability of perceptible interference, P_I, for a given percentage of time (time factor) can be derived from

$$k(P_I) = \frac{F_{um} - F_{dm} - time\ \ factor + R}{\sqrt{2} \cdot \sigma_L} .$$

The *time factor* relates to atmospheric signal propagation, which is small in relation to the fading interval of VHF mobile reception. Time variability can be removed from the equation for simplicity. Within local areas, wherein the pathloss is relatively stable for the desired and undesired signals, one can solve for the desired-to-undesired signal strength ratio due to Rayleigh fading, resulting from a given probability of interference:

$$R = k(P_I) \cdot \sqrt{2} \cdot \sigma_L - F_u + F_d$$

For a standard deviation of 6 dB, which is a common value in propagation studies,[29] and a 10% probability of interference the signal strength ratio of F_d and F_u is

$$R = 0.1 \cdot \sqrt{2} \cdot 2 = 0.28 = 11dB$$

The ratio *R*, is the effective de*crease* in protection relative to the median ratio for threshold interference. Thus, the interference under mobile fading can be substantially worse in the short term than the median conditions.

[29] Prediction of Urban Propagation Loss, Ranier Grosskopf, *IEEE Transactions on Antennas and Propagation, Vol. 42, No. 5*, May, 1994. This paper summarizes the literature on standard deviation

Appendix 3

Table of Experimental Facilities Filed for WRBJ-FM And reported by Roberson Technical Report

	Reported Name	Site Name	Structure Type	Lat. NAD83	Lon. NAD83	Max. ERP (H&V)	AGL (m)	AMSL (m)	Azimuth (°)	Stated Antenna
Original Request for EA, May 27, 2021	Node FM1		Existing Tower	32.276583	90.165083	210	20	101	305	Kathrein BCA CL-FM/RM log periodic
	Node FM2		Existing Tower	32.276583	90.165083	210	20	101	130	Kathrein BCA CL-FM/RM log periodic
	Node FM3		Existing Tower	32.316889	90.117639	170	20	102.6	322.5	Kathrein BCA CL-FM/RM log periodic
	Node FM4		Existing Tower	32.274361	90.204056	20	40	134.7	260	Shively 6025-2
	Node FM5	F	Existing Tower	32.343667	90.123472	30	55	138	345	Aldena ALP.08.02.712 (2x2)
Extension Request and Modification Nov. 29, 2021	Location FM5 (NW)		Portable tower	32.332333	90.126222	80	24.4	107	305	Log-periodic (Jampro or Scala)
	Location FM6 (SE)		Portable tower	32.332333	90.126222	80	24.4	107	125	Log-periodic (Jampro or Scala)
	Location FM7		Existing Tower	32.322583	90.156972	15	36	135	300	Log-periodic (Jampro or Scala)
	Location FM8		NA	32.239160	90.214722	175	30	112	200	Dual Scala Log-periodic
TECHNICAL REPORT Hwy. 25 Test	Derrick	A-SE	Tower	32.27663	-90.16511	240	24	-	135	Single log/single log pattern
	Derrick	A-NW	Tower	32.27663	-90.16511	240	24	-	315	Single log/single log pattern
	Jackson S.	B-SW	Tower	32.27389	-90.20500	200	45	-	210	Single log/dual log composite. pattern
	Jackson S.	B-W	Tower	32.27389	-90.20500	200	45	-	260	Single log/dual log composite pattern
	Savannah	C	Tower	32.23917	-90.21472	100	45	-	215	Dual Log pattern
	RiverSide	D	Tower	32.32289	-90.15744	30	45	-	300	Dual Log pattern
	Route 25	E-NW	COW	32.33213	-90.13548	65	21.5	-	310	Single log/single log pattern
	Route 25	E-SE	COW	32.33213	-90.13548	65	21.5	-	130	Single log/single log pattern
	Jackson N.	F	Monopole	32.34367	-90.12347	55	39.5	-	350	Dual Log pattern

Appendix 3 (cont'd)

Table of Experimental Facilities Filed for WRBJ-FM And reported by Roberson Technical Report

	Reported Name	Site Name	Structure Type	Lat. NAD83	Lon. NAD83	Max. ERP (H&V)	AGL (m)	AMSL (m)	Azimuth (°)	Stated Antenna
TECHNICAL REPORT I-20 and Hwy. 80 Test	Derrick	A-SE	Tower	32.27663	-90.16511	240	24		135	Single log/single log pattern
	Derrick	A-NW	Tower	32.27663	-90.16511	240	24		315	Single log/single log pattern
	Jackson S.	B-SW	Tower	32.27389	-90.20500	200	45		210	Single log/dual log composite pattern
	Jackson S.	B-W	Tower	32.27389	-90.20500	200	45		260	Single log/dual log composite pattern
	Savannah	C	Tower	32.23917	-90.21472	100	45		215	Dual Log pattern
	RiverSide	D	Tower	32.32289	-90.15744	30	45		300	Dual Log pattern
	Jackson N.	F	Monopole	32.34367	-90.12347	55	39.5		350	Dual Log pattern
	Hwy. 80	G-NW	COW	32.27839	-90.16344	200	20		315	Single log/single log pattern
	Hwy. 80	H-SE	COW	32.27839	-90.16344	200	20		135	Single log/single log pattern