Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of:	)	
	)	
Amendment of Section 74.1231(i)	)	RM- 11854
Of the Commission's Rules on FM	)	
Broadcast Booster Stations	)	

COMMENTS OF BERTRAM S. GOLDMAN
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My name is Bertram S. Goldman. I am the President of Goldman Engineering Management, Inc. I have over 40 years of experience in radio engineering. Over the course of my career, I have acquired substantial expertise in developing and facilitating improvements to radio stations, as well as overseeing construction and engineering operations. Over approximately the last five years I have been consulting with GeoBroadcast Solutions ("Geo"). Prior to founding Goldman Engineering, I served as Corporate Vice President of Engineering for several broadcast companies, including ABC/Disney Radio Division, Nationwide Communications, Patterson Broadcasting, and Shamrock Broadcasting. In my most recent group engineering position at ABC, I provided engineering oversight for all ABC O&O, ESPN, and Radio Disney stations as well as the ABC Radio Network. This background gives me unique perspective not only of station technical operations but also the business concerns of broadcast facilities. During my career, I have engineered numerous station improvement projects, including stations in more than half of the top 25 radio markets. I earned a B.A. in Broadcasting and Management from the University of Maryland, College Park. I am a member of the Institute of Electrical and Electronic Engineers ("IEEE") and the Society of Broadcast Engineers ("SBE"), and an associate member of the Association of Federal Communications Consulting

Engineers ("AFCCE"). I am active in the joint NAB/ CES National Radio Systems Committee ("NRSC").

I have significant and specific experience in the field of FM booster technology. And it was my background in booster technology that attracted me to this project undertaken by Geo. I have written and presented papers as far back as 1988 about booster technology at National Association of Broadcasters conferences.[1] I have designed boosters in several markets using propagation modeling as far back as 1989 which required running calculations on the NTIA computer mainframe in Boulder Colorado. Based on my extensive knowledge of radio engineering issues, my analysis of the underlying booster technology, and my observation of the tests that have been conducted in this technology, it is my opinion that the ZoneCasting™ system proposed by Geo can be launched without causing harmful interference, either to the station launching the system (*i.e.*, self-interference), or to other broadcast licensees.

Before turning to a discussion of ZoneCasting, it is important to first discuss a related technology, MaxxCasting, that forms the basis for ZoneCasting. Since 2015, I have been working with Geo to develop multiple node (multiple transmitter) booster systems known as MaxxCasting systems. MaxxCasting systems use multiple boosters synchronized both with the main transmitter and with each other to produce nearly seamless transitions between node areas. MaxxCasting improves coverage beyond what would be possible with only the main transmitter by filling in low signal areas within an FM station's protected service contour. MaxxCasting has now been successfully deployed in Boston, West Virginia, Tampa, Miami, Milwaukee, Chicago, Seattle, San Diego, and Los Angeles, and is expanding rapidly. The San Diego implementation

[1] Goldman, Bert and D. Gooch, "Designing and Modeling High Power FM Boosters," 1988 NAB Engineering Conference Proceedings.

of MaxxCasting, for the first time, incorporates both analog and HD digital operating seamlessly on both the main and all booster nodes. MaxxCasting is able to achieve interference-free signal improvement due to four techniques Geo has employed, which essentially "trick" the receiver into thinking that it is hearing one station instead of two or more (otherwise resulting in distortion and interference). These techniques are:

A. Carrier synchronization, now possible by using GPS-trained oscillators.

B. Pilot phase synchronization, also possible using GPS.

C. The use of small cells with highly directional antennas to keep the real-time FM waveforms at the receiver to within three microseconds. Accurate RF modeling and prediction, critical in optimizing performance, is accomplished with powerful software tools developed by the wireless industry for cellular communications. This allows Geo to precisely tailor parameters to maximize coverage and minimize interference.

D. Maintaining the audio modulation of the main and booster FM carriers to identical waveforms with less than a 0.1 dB difference between the main transmitter and all nodes when in MaxxCasting mode.

ZoneCasting is based on MaxxCasting technology. The difference is that during limited times, ZoneCasting broadcasts localized information only on specific booster nodes, meaning that this information—which could be advertising, programming, or emergency alerts—only reaches the specific nodes' local area, or "zone." Due to the differing content, since identical waveforms cannot be generated, ZoneCasting still makes use of the above techniques with some modifications. Techniques A and B remain synchronized. The antennas in technique C still tightly control where the different programming goes and tightly roll off the signal at the edge of coverage to keep any self-interference minimized. To minimize the transition zone between the main station's programming and the separate zoned location's programming, a second antenna is added to each node's antenna and pointed 180 degrees away from that of the first antenna, transmitting a low power signal matching the main station's programming. By doing this, a listener traveling between zones experiences only a very small area where the audio transition is noticeable. In the most recent testing in Milwaukee, due primarily to cost constraints, the transition area was limited to one tenth of one percent of the station's coverage area. Depending on design, this could be further reduced.

Since all other parameters remain in synch, the listening experience is not perceived as interference, but rather just a transition of audio from one stream to another. In contrast, many currently licensed boosters not using the techniques enumerated above to mitigate interference have interference areas that take up 20 percent or more of the primary station's coverage area, even though the boosters are strictly retransmitting the primary station's signal. This large amount of destructive self-interference generated by many current boosters is allowable under current booster rules as long as that interference does not take place within the community of license. ZoneCasting, even with different programming between the main and zones reduces the amount of self-interference by orders of magnitude below that generated by many authorized boosters on the air today.

Finally, with respect to technique D (maintaining modulation within 0.1 dB), based on our ongoing tests, we have found that maintaining modulation peaks as close to identical as possible (even though the nodes are broadcasting different content) further helps reduce the perception of transition between zones.

ZoneCasting is the product of nearly ten years of development and testing. Since its inception, Geo has significantly contributed to the technology and usefulness of on-channel boosters, both for same-content and differing content operations. The first ZoneCasting proof of concept was conducted pursuant to an FCC experimental authorization in Salt Lake City, Utah on KDUT in 2010. Geo used an existing array of boosters with no changes other than feeding different program content to different booster nodes. Stationary measurements were taken in many locations in and around Salt Lake City to determine the efficacy of the ZoneCasting concept. Due to natural terrain blockage, relatively good performance was experienced and documented; however, no mobile testing was conducted. Based upon comments from FCC staff following the initial 2010 test, Geo conducted its second test of ZoneCasting under an FCC experimental authorization in flat terrain in Sebring, Florida on station WWOJ. In this test, custom log-periodic antennas were designed and set up in strategic locations to better define the zoned broadcast areas. Automated quality testing was implemented using an Audemat MC3 FM modulation analyzer. Quality measurements were recorded using a five-point scale and comparisons were made with and without the zoned operation at the same fixed locations. This test gave Geo important information as to the effect of D/U (Desired to Undesired) signal levels and how they affect quality.

After the above two field tests, Geo concluded that better data was necessary to determine how booster signals propagate (both with and without separate programming) so that reliable prediction of service could be measured, and signal quality could be maximized. This led to the introduction of new tools to predict propagation, such as the ATDI ICS Telecom software. Much work was done to develop extremely accurate propagation modeling tuned with signal measurements from the field. Further, it was determined that there was little available data regarding the effect of D/U ratios and other factors (as noted above) on reception quality and what level of interference would typically be tolerated by listeners. In 2013, Geo contracted NPR labs and Dr. Ellyn Sheffield of Towson University to conduct subjective listening tests[2] in much the same way that HD Radio proponents tested that technology 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.

Following the extensive testing and development that took place between the initial 2010 and 2012 field tests and the most recent field test—conducted in 2016—Geo developed new, significantly improved design criteria for booster systems. Geo successfully implemented MaxxCasting booster systems with a high degree of quality and repeatability, that could work consistently in all terrain. Based upon the work done in MaxxCasting design, the ZoneCasting design criteria was modified to add a second antenna back-to-back with the zoned antenna which carried the main programming. This modification allows for a very fast transition in a mobile environment and significantly improves performance of the ZoneCasting system.

With the success of the MaxxCasting design, Geo and WIIL in Union Grove, Wisconsin tested the new ZoneCasting design pursuant to an FCC experimental authorization in the fall of 2016. In this test, four ZoneCasting nodes were set up in central Milwaukee, Wisconsin. During periods where the zones replicated the main audio, the system operated in MaxxCasting mode.

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[2] Design Parameters for Analog FM Signal Repeaters Based on Listener Testing, Ellyn Sheffield, Melinda Hines [Towson Univ], John Kean [NPR Labs], Available at https://www.geobroadcastsolutions.com/news-press

In MaxxCasting mode, WIIL's signal quality in central Milwaukee drastically improved. When the ZoneCasting process was implemented, field tests showed that the transition from main to zone in a mobile environment could be reduced to such a short period that it is believed consumer tune-out would be unlikely. WIIL with Geo filed the full report with the FCC in February 2017.[3] The results are impressive and demonstrate that the deployment of ZoneCasting did not cause harmful interference to other broadcast facilities, and that self-interference experienced by listeners was limited to only a few city blocks, for a very limited period of time.

Geo-targeted booster systems use off-the-shelf, non-proprietary hardware as building blocks of the ZoneCasting system. While Geo uses some proprietary processes and data in the design of ZoneCasting systems, any broadcaster could develop their own data and processes to build their own zoned SFN broadcast system.

Work on ZoneCasting has been ongoing as have been further refinements in the technology. It is expected that, as with any technology, refinements and improvements will be ongoing if the technology is allowed to deploy. Indeed, work is currently underway in the Geo lab to define the Hybrid HD radio listener experience and the results are quite promising.

In conclusion, in my professional opinion the geo-targeted, zoned SFN has achieved a level of performance where large-scale implementation may be undertaken and only minor "tweaks" would be necessary in any particular market. The FCC requirement found in Section 74.1231(i) of the Commission's rules that requires booster programming for full power FM stations to be identical to the main station is no longer necessary to guard against harmful interference either to (i) other broadcasters in the market or (ii) to consumers listening to the

[3] GeoBroadcast Solutions ZoneCasting FCC Report, February, 2017, available at: https://www.geobroadcastsolutions.com/news-press

main station. Due to advances in synchronization technology and RF modeling, it is now possible for synchronized boosters to not only improve coverage in shadowed areas, but also within a station's general coverage area, allowing special targeted information to be delivered with no harmful interference to listeners in the small controlled transition areas. The value offered to FM broadcasters for limited, separate geo-targeted SFN's is significant and should be available as a tool to broadcasters who voluntarily choose to implement it to better serve their listeners and advertisers.

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Bertram S. Goldman
May 4, 2020