

# *How to Build An Audiophile Car Stereo System, an Interview with Jon Whitledge*

## We Talk to the Man Behind the Story

Jun 24, 2010

Introductory note by Ben Oh:

If you've been following the "How to Build an Audiophile Car Stereo System" series and have read our feature on Jon Whitledge's Volkswagen camper van which was first featured in the January 2004 issue of *Car Audio and Electronics* magazine ("CAE")<sup>1</sup> then you're well aware of the level of passion Jon has for audio. He has amassed nearly a dozen 1st-place trophies in sound quality competitions from a variety of organizations (IASCA<sup>2</sup>, USACi<sup>3</sup>, and SLAP<sup>4</sup>) when he competed regularly. He was IASCA's "Rookie of the Year" for the Pacific Southwest Region in October of 2003 and, since then, Jon has been certified as an IASCA sound quality judge, and has dedicated his efforts to creating a new sound quality competition vehicle. It was while fabricating and tuning his new vehicle that he composed a six-part series of articles for CAE, which comprised of about 28 pages of technical information.<sup>5,6,7,8,9,10</sup> We've been providing the new edited versions on the site (part 3 of his series continues shortly) that a lot of you are reading for the first time (we will be actually extending the articles beyond the initial six parts).

In the fall of 2008, Jon's vehicle was featured on the cover of the December 2008 issue of *the abso!ute sound*® magazine as "The World's Best Car Stereo".<sup>11</sup> This was the first time in the magazine's history that a car stereo had ever been featured and reviewed.

For those of you who are interested and missed it, here's the video of Jon explaining the various design goals and features of his [front sound stage](#).<sup>12</sup>

Because of his achievements thus far in car audio and because of the interest readers have shown, we thought we would run this interview we conducted earlier on during the construction of the Sprinter.

**CAE:** Tell us about your background.

**JRW:** I think most people are aware that I don't possess a long and illustrious career in car audio like so many others do. Instead, my background is based on academics and corporate achievements in engineering and science. I studied mechanical engineering in college. I attended the University of Akron's Mechanical Engineering Technology program where I earned my Bachelor of Science degree. The coursework was particularly relevant to industry, and I found myself particularly attracted to courses in CAD, CAM, robotics, controls systems, mechanical design, machine tools technologies, engineering economics, technical writing, and management principles.

After graduating Magna Cum Laude with my Bachelor's degree, I accepted a position with a subsidiary of Swagelok, arguably the finest maker of valves and fittings, as a manufacturing engineer. In this position, I modified and designed production line equipment. When the opportunity arose to work briefly in the R&D department, I jumped at the chance. From this experience, I felt I must return to school to acquire a graduate degree. My friend, Scott, urged me to study polymer science (remember the scene in "The Graduate"? "I have one word to say to you—plastics").

So in 1988, I was accepted into the internationally renowned College of Polymer Science and Polymer Engineering. I owe a great deal of gratitude to Dean Frank Kelley, who allowed me to enter his prestigious program and accepted me as one of his students. I think he was attracted to two of my key talents, one of which was my ability to operate a milling machine to create intricate polymeric test specimens, and the other was my ability to write technical documents. Because of my mechanical engineering background, the emphasis of my coursework involved structure-property relationships of polymers. I gravitated toward courses in rheology, fracture mechanics, macromolecular characterization, rubber technology, surface science (adhesion), experimental stress analysis, and numerical analysis. Interestingly, my graduate research was among the first in a field now known as "nanotechnology". I evaluated the effects of incorporating graphite microtubules into matrices of thermoplastic and thermosetting resins, thereby creating "nanocomposites" as they are referred to today.

Before I graduated, I found myself inundated with offers of employment from numerous Fortune 500 companies, including Kimberly-Clark, National Starch, Rogers Corporation, and Reynolds Metals Company. I chose to go with Reynolds

Metals Company in Richmond, Virginia. As their only Polymer Scientist, I worked as a “polymer guru” for many of their divisions, including packaging, construction products, and others. Reynolds groomed me for management, and gave me the opportunity to establish working relationships with great scientists from VPI&SU (“Virginia Tech”), Virginia Commonwealth University, and Rensselaer Polytechnic Institute, among others. After a few years at Reynolds, forces in life began pulling me to San Diego.

**CAE:** When we met you, you were working in the biotech industry though.

Yes, in San Diego, I transitioned my polymer skills to the new and emerging field of biotechnology. I was one of the first polymer scientists to work for a commercially thriving biomaterials company. One of my first and most important projects in biotechnology involved the design and fabrication of a robotically actuated protein solution spraying station. This married my manufacturing engineering experience with my knowledge of polymer science. After this project, my research focused on creating and characterizing a biocompatible, biodegradable, tissue adhesive suitable for internal wound closure, in collaboration with the scientists from Johnson & Johnson.

**CAE:** How the heck did we get from there to car audio? Do you feel that your background translates well to this field?

**JRW:** Yes, absolutely! I feel that among the many important aspects of design in audio, materials science is certainly foremost among them. Consider, if you will, the aspects of design associated with a loudspeaker. Materials scientists constantly strive for new ways to make stiff, lightweight, loudspeaker cones, and they are typically made from a diverse array of materials including diamond, ceramics, composites, exotic metals, paper, silk, and mineral-loaded polymers. Voice coils are often times wound on polymeric or composite formers, and let’s not forget about the rubber surround. Most loudspeaker wires are insulated with polymeric materials, such as PTFE, FEP, and PVC. Because of these examples, and many more, I believe the field of polymer science contributes greatly to the advancements in audio. I believe that my background in both mechanical engineering and polymer science, combined with my industrial fabrication experience, helped me to successfully engineer solutions to overcome the challenges imposed by the car audio environment. Also, as a scientist, I feel I have the ability to read and interpret research papers written in fields outside of my expertise, and learn quickly from them.

**CAE: What first got you into car audio?**

**JRW:** My uncle got me into home audio when I was about 21. He shared with me the marvelous, indescribable fun provided by hearing music reproduced in a lifelike manner. By the time I was 28 years old (1988), I could afford, and acquired, a modestly-priced, two-channel home audio rig. When I was 32, I started making some pretty good coin, and stepped up to the plate with a selection of "B-grade" high-end components. Later, as I became increasingly enamored with the hobby, I upgraded some of my components to the "A-grade" level. After a few years of enjoying my home audio rig, I found my lifestyle had changed a bit, due to the stresses imposed upon me by the corporate working life. I liked to get away to the desert, mountains, and beach, where I could relax, and escape the mayhem of plant floors and research laboratories. But wherever I went, I missed my home audio rig. So in 1996, when I bought my first Volkswagen EuroVan Camper, a pre-owned 1995 model, and I installed a modest 4.1-channel audio system. When that van had acquired in excess of 100,000 miles, I retired it from duty, and acquired a brand-new 2001 EuroVan Camper. That's the one previously mentioned that was featured in the magazine. What's funny about that van is that I had little or no awareness of car audio competition. I simply built it according to my own standards for quality, craftsmanship, and sonic performance. I used my experience with high-end two-channel audio to guide my efforts. On a whim, I decided to enter a local competition, and won 1st-place. You and your readers know the rest of the story...

**CAE: What inspired you to build the Magic Bus?**

**JRW:** Several things. First, at the 2004 CES, I met with car audio guru, Peter Lufrano. He surprised me when he said, "I like your work and I want to get behind you". I was very appreciative of that, as you might imagine, and found the proposal interesting. Later that day, I left the convention center to go over to the high-end show at Alexis Park Hotel. My intention was to meet legendary audio designer, Steve McCormack<sup>13</sup>, to introduce myself and discuss some of my design ideas. When I met Steve, he remembered me from when I visited his store with my uncle some years prior. He graciously invited me to his laboratory to listen to my EuroVan, the one that had won ten 1st-place trophies. So later that month we met, and Steve heard my system. Although Steve complimented many aspects of the system's performance, there were some deficiencies he easily identified within about 30 seconds. Steve's constructive criticisms, combined with feedback from prestigious IASCA judges like Mark Eldridge and

Harry Kimura, made me wonder if my EuroVan provided an appropriate platform for my inevitable promotion to a higher competitive class.

Since 2001, when the Mercedes Sprinter vans reached American soil, I had been interested in them. In 2004 they became 50-state legal, which meant I could own and operate one in California. Several aspects of this van's design, as described in my articles, made its use as my audio platform quite attractive. Throughout 2004, I began to formulate a plan, and wrote numerous proposals for acquiring sponsorship. With several sponsors in place, and a pile of money from the sale of stock options, it seemed as if the project could move forward. So I ordered my new Sprinter van around the summer of 2004 and waited five months for my Sprinter to be custom-built in Stuttgart, Germany. I took delivery on December 4th, 2004, and began fabrication the next day.

**CAE:** What were your design goals with the Magic Bus?

**JRW:** First and foremost, back in 2004, I wanted to build an audio system capable of winning IASCA's "Semi-Pro Street Class". According to the IASCA's current rules, the new name for this class has been changed to "Pro Class". In any case, the important point is that judging is conducted from the driver's seat, so my van is designed entirely with the goal of optimizing the sound for the driver's listening position. Even though, my series of articles goes into great detail about why and how I built the Magic Bus, there exists a deeper, underlying, philosophical reason why I did the whole project as I did.

First, since I've only won 1st-place trophies at competitions, the idea of getting a second-place trophy seemed unappealing. After all, if one is serious about competition, one's goal must be to avoid second place. I believed my EuroVan, while quite good in sound quality, provided enough limitations to endanger my competitive efforts with a 2nd-place trophy.

Second, my EuroVan was only a few points short of achieving a perfect installation score, so although I could have implemented corrective action on the EuroVan, I wanted to start with a "fresh slate" and address all facets of the install judging criteria to ensure a perfect install score. I knew that as I aspired to a higher competitive level, I could not afford to lose points needlessly, as it was not difficult to imagine other skilled installers also achieving perfect installation scores.

Third, I felt the use of an exotic supercar, or high-performance sports sedan, while visually seductive, would result in severely compromised interior acoustics. Based on reverberation time theory and practice, I knew I needed a vehicle with the greatest internal volume available. It seemed pointless to me to try to build a competition-winning car by starting out with compromised acoustics. In the future, readers of this article will see and hear the full impact of my research, which is secretly being implemented at the time of this interview.

Fourth, in an industry rife with fancy fiberglass, custom paint, chrome wheels, motorized widgets, and neon, I wanted to create something special that stands on its own as a triumphant achievement in engineering and audio. I wanted to create the simplest system, one where every ounce of effort serves the sound; one where science and art meld into one, delivering a revelatory sonic experience. To me, this means the fewest trim pieces, no motorization, no fancy paint, just solid engineering. I think it's clear by now, with my background in engineering and control systems, that if I wanted to create a "high bling" system, I easily could have. For me, the philosophy was simple; if it didn't serve the music, it didn't belong in the Magic Bus.

Finally, I wanted to implement other novel concepts, besides room acoustics, in the field of car audio. As far as I know, I'm the first person to incorporate the following novel ideas into a car audio system:

1. Overhead electronics with the shortest possible interconnects and loudspeaker cables.
2. Front monitors comprising of super heavy (24 pounds each), highly damped enclosures, featuring contours with radii of unprecedented magnitude to minimize diffraction.
3. Sealed door enclosures, isolated from the interior door panels, each housing a 9-inch (nominal size) woofer, and each enclosure isolated from their respective door with rubber isolators. Each door enclosure weighs 35 pounds. Each interior door panel weighs 15 pounds.
4. Exclusive use of WBT audio connections, and audiophile-grade loudspeaker cables and interconnects.
5. Sealed subwoofer enclosure, laminated from 18 layers of Baltic birch, which weighs in excess of 300 pounds, decoupled from the body of the vehicle with military-grade generator mounts with a natural frequency of 11 Hz.
6. Operating the subwoofer below the resonant frequency of the system.

7. Yet to be revealed, interior acoustical modifications of unprecedented effectiveness, rendering the interior reverberation time spectra of the van to be on par with that of the finest recording studios.
8. Voicing and tuning of the car audio system by Steve McCormack.
9. Use of Bosch Rexroth structural aluminum framing for interior structures.

As a scientist, I'd hoped that implementing these ideas would translate into an improved listening experience. After all, theory is useless if it doesn't translate into practice. In reality, building this van, and its audio system, was an exercise in faith. I had to believe that the implementation of these novel ideas, to the best of my ability, would directly translate into meaningful performance-based results. Every step of the way in this project, I attempted, in the most objective way I could, to assess the value of what I had done. I had to ask myself "Did I accomplish my goals? Did I achieve an improvement, or worst case, did I not harm the performance?" I'm pleased to say I've made few, if any, missteps during this project. Perhaps I can attribute this to 22 years of scientific technique combined with significant project management experience. Definitely, substantial credit must be given to Steve McCormack for his creative and helpful design input. Based on Robert Harley's review, combined with feedback from musicians, I'd say these novel ideas really did translate into a "real-life", practical improvement in the listening experience.

**CAE:** Nobody's going to drive a Sprinter van (although of course we know for you it's a daily driver), or go to the lengths you did to achieve great audio; how does your Magic Bus relate to the consumer? What is the real value of the Magic Bus to the industry?

**JRW:** You are absolutely correct, so I will attempt to explain how I hope and believe my van relates to consumers. I'll be the first to admit, it's not easy owning a van this big, which is chock full of expensive audio equipment. I have to be careful where I take it and where I park it. It's not easy using this van as my daily driver.

First, let's talk about the van itself. Believe it or not, every day someone approaches me out of curiosity, either to learn about the Sprinter van itself, or to see what I do with mine. When I go to parties, the topic almost always turns to what I do for a living. When I describe my love for audio, people want to hear it play. Even the clients of my chiropractor and cosmetologist ask about my van

(incidentally: my chiropractor and a famous musician bought Dynaudio loudspeakers after hearing my van; my accountant bought Cascade Audio sound treatment products, too.).

When I attended the Rocky Mountain Audio Fest, I was so inundated by listeners, I had no time to take a break or even take lunch. **One distinguished gentleman, in particular, stopped by to listen to my van. I played for him “Spanish Harlem” by Rebecca Pigeon. While the song played, he turned rearward to view the motion of the subwoofer cones: they were moving at inaudibly low frequencies. At the completion of the song he turned to me and said, “I designed the equipment for this recording, and I was present when it was made. You’ve got it right, I used no subsonic filtering”.** [Our emphasis. Ed.] Later, another gentleman stopped by, this time to play his CD. He told me he was a recording engineering and wanted to hear his recording he’d made of a drum kit. We proceeded to play his recording, which was with different microphones and different microphone placements. It was dynamic and lively, and quite an impressive recording. When it was finished playing, he sat in amazement and admitted to me that he’d taken this CD inside, to many of the high-end exhibits, yet my van outperformed everything he’d heard inside at the show!

On August 23rd, 2008, Alpine hosted a 30th anniversary celebration at their headquarters. It was my honor to be invited by Alpine to exhibit in front of the entrance to their corporate headquarters at this prestigious event with all of Alpine’s famous personnel mingling amongst the attendees. It was, by far, the best audio event I’d ever attended. The event lasted until 6:00 PM, when everyone packed up and went home. I, on the other hand, due to the demands of listeners, stayed until 10 PM. I’ll never forget that night—a few audio enthusiasts and I sharing our love for something special.

One night, I was at a Brazilian party and there was an elderly gentleman there, sitting alone, rather uninvolved with what was happening. Some sort of emotion overcame me, so I approached him and said, “I’ve got something for you to hear”. Curiously, he arose from his chair and followed me out to my van. I played for him Ana Caram’s “Meditation” from Rio After Dark (Chesky Records). He closed his eyes and listened silently throughout the song. At the conclusion of the song, he said, “I was in Rio at the inception of Bossa Nova, and every time I hear this music, my heart flutters”. For the rest of the evening, we enjoyed the remainder of “Chesky’s Jazz Sampler & Audiophile Compact Disc” (JD37). We have been friends ever since that night.



The Magic Bus has created stories like these that are too numerous to tell -- each slightly different, but the same in many ways. The ability of this van to connect with people in ways I had not imagined continually astonishes me. It brings people together through a medium that binds us all together -- music. Could a Ferrari or a Bentley with a typical audio system do this? I doubt it.

I believe the car audio industry must return to its roots in sound quality, and I hope my Sprinter van leads the way. I hope my van makes industry leaders stop and think about the value of producing sensational show cars year after year, where the emphasis seems to be more on the car itself, rather than the audio products contained within the car.

**CAE:** Tell us the story behind the musician autographs for the van.

**JRW:** Actually, the idea hit me at a party. We were at Jim Merod's house after a performance by Noel Jewkes was recorded.<sup>14</sup> Essentially, on an impulse, I invited Mr. Jewkes, a renowned saxophonist, to autograph the subwoofer. This autograph was the first of many to follow. I believe the autographs have the following importance. First, I believe that having a musician hear my system, and subsequently autograph it, validates the sound quality I've achieved. The compliments regarding the realism of my system are simply too numerous to discuss in this interview. Second, now that I've acquired critical acclaim for my audio system's performance, the numerous autographs now commemorate the musicians who have performed in southern California—like a time capsule. I consider my van to be a shrine for musicians, with a virtually priceless collection of autographs from legendary jazz and classical musicians. I truly believe and hope that, someday, the Magic Bus will be on display at a museum, proudly commemorating the great contributions musicians have made to our lives.

**CAE:** If your car sounded so good for Robert Harley, why didn't you start competing immediately thereafter?

**JRW:** I must admit that the publicity surrounding my van may have misled people. Unlike most builders, I "unveiled" my project well before it was completed. For that matter, well before it was tuned completely. I thought by doing so, I could garner industry support and increase my level of sponsorship. Really, what people needed to realize is that my van was first assembled for purposes of proof-of-concept. When Mr. Harley heard my van, it was at its peak in that particular development cycle. But the interior was still unfinished. I kept the system together and playing for as long as I could, which corresponded to

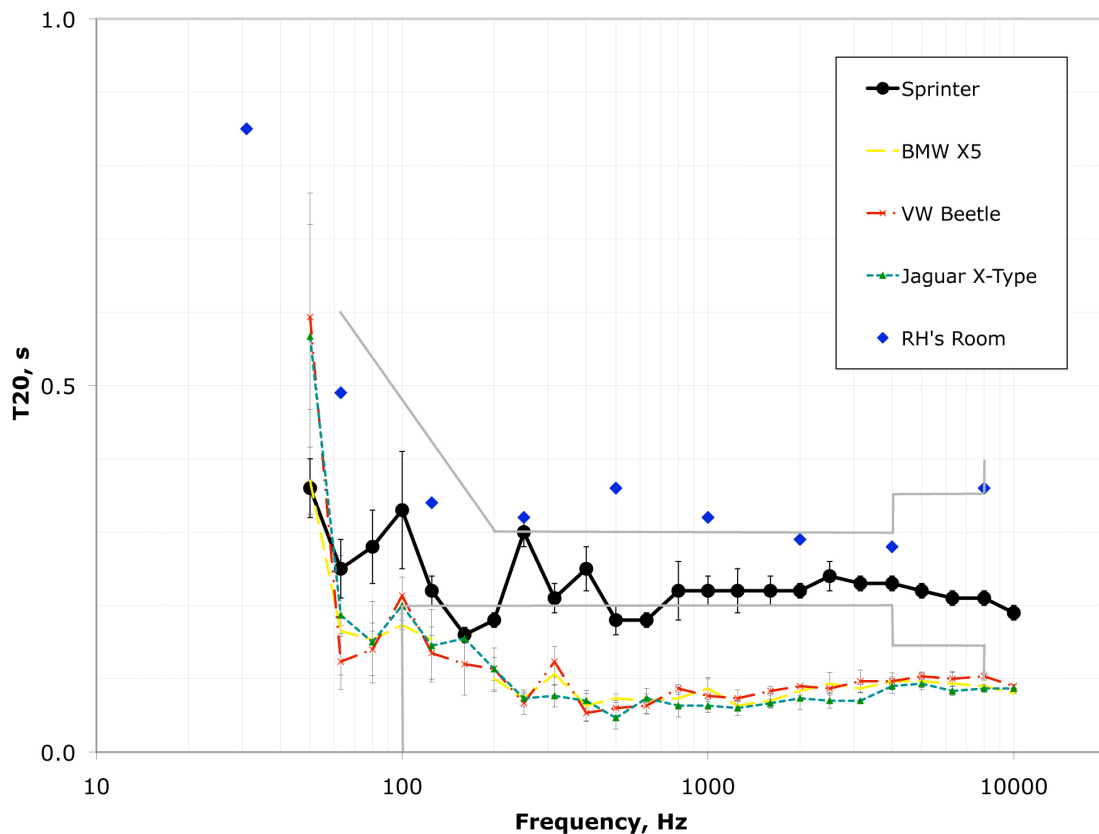
Alpine's 30th anniversary celebration. On August 24th, 2008, I dismantled the entire system to work on the interior headliners and acoustical treatments. The system has not played since that time, over one year later. However good the system was when Robert Harley heard it, I had significant plans to improve the sound even further with acoustical treatments and other changes I have yet to reveal. So to answer the question, I felt the system was not completed, nor was it at its potential, according to my plans. I felt that it was inconsistent with my goal of achieving a perfect installation score, when the installation could not be judged. Furthermore, I did not plan to compete until the acoustical treatments were done.

**CAE:** You no longer work in the biotech industry. What have you been doing professionally?

**JRW:** I formed Whitledge Designs in 2004 when, after considerable soul searching, I concluded that transitioning my talents to the audio industry was what I wanted to do. I offer audio and polymer consulting. Since I've formed Whitledge Designs, I've installed numerous car and home audio systems for clients, and I've tuned several cars. I've put a lot of work into my website. It has a lot of information about my car audio system and car audio in general. At my site you'll find 487 photos of the fabrication process (each photo with a caption), along with the measured frequency response of the system. In addition, you'll find information about musical artists, publications, shows, and much more. More than anything, I hope my website is inspirational and informative to those who love all things audio.

**CAE:** What specifically have you been working on lately?

**JRW:** For about the last year, I've been working on the interior of the van. During this time, I've created five headliner sections, 22 interior wall panels, eight window valances, and four trim pieces. The fabrication of these items was rather involved, and was largely guided by acoustical considerations. Although my work is not yet finished, I would like to share the results of some of my preliminary work, which I believe readers will find quite revolutionary. Using equipment, techniques, and acoustical treatments I'd prefer not to reveal at this time, please refer to the plot below:



The plot shows reverberation time, in seconds, as a function of frequency, in Hertz (“Hz”). The reverberation time, by definition, is the time it takes sound to decay 60 dB. In practice, it is difficult, and sometimes impossible, to measure 60 dB of sound decay. Typically, a portion of the sound decay (10, 20, and 30 dB drops, for example) is measured then mathematically extrapolated to 60 dB. In the case of my measurements, the “T20” method was used. The instrument I used (state-of-the-art sound meter from a prestigious manufacturer) determined the reverberation times for frequencies ranging from 50 to 10,000 Hz in 1/3-octave intervals. The gray lines on the plot define the upper and lower limits for reverberation time, according to the International Telecommunication Union (“ITU”).<sup>15</sup> Not only did I measure the spectra of reverberation times in my preliminary-treated my Sprinter (indicated by black solid circles), but also for other vehicles, including a BMW X5 (dashed yellow line), a VW Beetle, (red crosses), and a Jaguar X-Type (green triangles), all for the sake of comparison. For further comparison, I also obtained published data from Robert Harley’s personal listening room (blue diamonds).<sup>16</sup>

First, I'd like to discuss the reverberation times in what represents a typical selection of automobiles. The plot clearly shows that all typical automobiles have insufficiently short reverberation times (about 0.1 seconds) throughout the midrange and treble, that are roughly half the magnitude required to comply with the ITU guidelines. This would give typical automobiles a "dry" lifeless sound, and little indication of spaciousness. The plot also reveals problems with the bass in typical cars; notice how the reverberation times below 100 Hz rise rapidly. The disproportionately long reverberation times in the bass, relative to those in the treble and midrange, are undesirable, and lead to sonic degradation.

As for the reverberation times in the Magic Bus—notice how the spectra of reverberation times are essentially within the guidelines set for by the ITU. If one wishes to be critical, it is true that there is a small peak at 250 Hz, a small dip at 160 Hz, and another slight dip between 500 and 630 Hz, but these are minor imperfections when compared to the gross deficiencies of conventional automobiles. Also notice how the reverberation times in the bass rise only modestly relative to those in the midrange and treble. I'm quite pleased with the outcome of my acoustical treatments. My preliminary listening impression validates that they are as important as any component in my audio system, and have resulted in a dramatic improvement in the sound quality. With regard to the value and effectiveness of room treatments, Robert Harley summed it up best, "If given the choice between listening to \$40,000 worth of preamp and monoblock amplifiers and no room treatment, or a \$2,500 integrated amp and the ARS package, I would choose the lesser electronics in the treated room. Room acoustics are that important, and the ARS package is the ultimate realization of the goal of minimizing the room's effect on music reproduction."<sup>17</sup> Although reverberation time is only one important measure of a room's performance, I'm delighted the reverberation times in my Magic Bus essentially comply with ITU's guidelines and compare favorably to not only Robert Harley's extraordinary listening room containing treatments valued at \$33,000, but also to some of the finest recording studios. I'm excited to finish my van and share the results of my extraordinary and unprecedented acoustical treatments with mobile audio industry specialists and mobile audiophile consumers.

**CAE:** *When will the Magic Bus be finished?*

**JRW:** I think it will be done in few months, say early fall [2010]. However, if there were one thing about this entire project I haven't done well, it would be predicting the completion date. With a project of this magnitude and importance, I feel it would be counterproductive to set a strict deadline. Furthermore, I would not

want to make compromises in quality simply to achieve a deadline. So as I do my work, I focus on doing my best at each moment, rather than the amount of time a particular task takes, knowing that the finished product will represent the sum of those moments.

**CAE:** *Where do you see yourself and Whitledge Designs in the future?*

**JRW:** When the Magic Bus is finished, I'll turn my attention to a variety of possibilities, including building systems for high-profile clients, performing consulting for audio companies, conducting original research on specialized polymeric materials for audio products, doing product design, development, and testing, continue freelance writing about audio system design or branch out into product testing, work with OEMs to further improve their offerings to automotive consumers, and compete and exhibit at shows across the country. I hope to grow my list of sponsors. In particular, I'd like to acquire additional sponsorships from manufacturers of wheels, tires, lubricants, car care products, and others. I think it would be appealing to spearhead a grassroots effort to grow both the car and home audio industries' consumer base.

**CAE:** *The Magic Bus is unique within the audio industry and I can't wait to hear it when it is finished. Thanks for taking to the time to share with us a more information about the Magic Bus and Whitledge Designs.*

**JRW:** My pleasure, Ben. You'll undoubtedly be among the first to hear it when it is finished. In addition, you, and the staff of CAE, will also be invited to my sensational, and very exclusive, completion party I've been planning.

## REFERENCES

1. Rob McPherson, "Weird Science", *Car Audio and Electronics* magazine, Jan 2004, vol. 17, No. 1, pp. 58-64.
2. International Auto Sound Challenge Association, <http://www.iasca.com/>.
3. United States Autosound Competition International, <http://www.soundoff.org/>.
4. Sound, Looks, and Performance, <http://www.slapshow.com/>.
5. Jon Whitledge, "The Car Audio System Nobody Would Build, Part 1", *Car Audio and Electronics* magazine, Jun 2008, vol. 21, No. 6, pp. 68-73.
6. Jon Whitledge, "The Car Audio System Nobody Would Build, Part 2", *Car Audio and Electronics* magazine, Jul 2008, vol. 21, No. 7, pp. 22-25.
7. Jon Whitledge, "The Car Audio System Nobody Would Build, Part 3", *Car Audio and Electronics* magazine, Aug 2008, vol. 21, No. 8, pp. 24-28.
8. Jon Whitledge, "The Car Audio System Nobody Would Build, Part 4", *Car Audio and Electronics* magazine, Sept 2008, vol. 21, No. 9, pp. 34-36.
9. Jon Whitledge, "The Car Audio System Nobody Would Build, Part 5", *Car Audio and Electronics* magazine, Oct 2008, vol. 21, No. 10, pp. 64-68.
10. Jon Whitledge, "The Car Audio System Nobody Would Build, Part 6", *Car Audio and Electronics* magazine, Nov 2008, vol. 21, No. 11, pp. 72-76.
11. Robert Harley, "Magic Bus: The Ultimate Car Stereo", *the absolute sound*, Dec 2008, issue 188, pp. 50-56.
12. visit "[SQ Sprinter Frontstage](#)".
13. Steve McCormack is a world-renowned audio component designer with more than 30 years of experience in high-end audio. Visit <http://www.smcaudio.com/>.
14. Jim Merod is a world-renowned recording engineer who has recorded a "who's who" of legendary jazz, blues, and Latin musicians. His recordings are released under the BluePort Jazz label. To learn more about his fabulous recordings, visit [BluePort Jazz](#).
15. Bjorn van Munster, "Beyond Control: Acoustics of Sound Recording Control Rooms -- Past, Present and Future", Eindhoven University of Technology, April 1 2003, p. 78.
16. Robert Harley, "The Cutting Edge: Acoustic Room Systems (ARS) Room Treatment", *the absolute sound*®, Dec 2002/Jan 2003, p. 121.
17. Robert Harley, "The Cutting Edge: Acoustic Room Systems (ARS) Room Treatment", *the absolute sound*®, Dec 2002/Jan 2003, p. 124.