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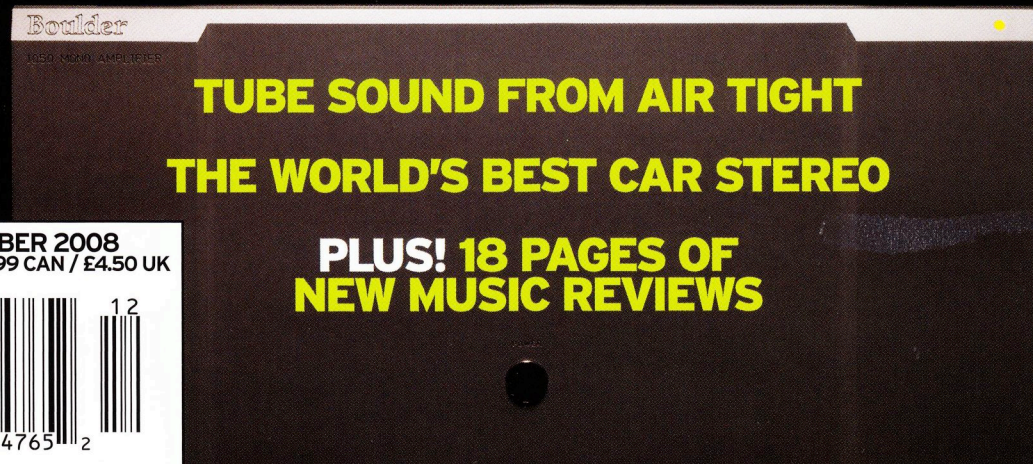
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Magic Bus: The Ultimate Car Stereo

JON WHITLEDGE

Introductory note by Robert Harley: *One of the best-sounding audio systems I heard at the 2008 Consumer Electronics Show wasn't in one of the official high-end exhibits, but in a van sitting in a hotel parking lot. How could a "car stereo" outperform many high-end home systems employing freestanding loudspeakers in hotel rooms? The answer is that this system transcends any notion of conventional in-car audio—the van was purchased solely with the intent of creating the world's best mobile audio system by applying high-end audio ideals and technologies to the mobile environment.*

The van's owner, Jon Whitledge, spent the over three years and more than 4000 hours on fanatical design and meticulous craftsmanship to create what must be the ultimate mobile audio system.

I was so impressed by the sound, design, and high-end aesthetic of Whitledge's "Magic Bus" that I asked him to share with TAS readers details of the system's design and construction.

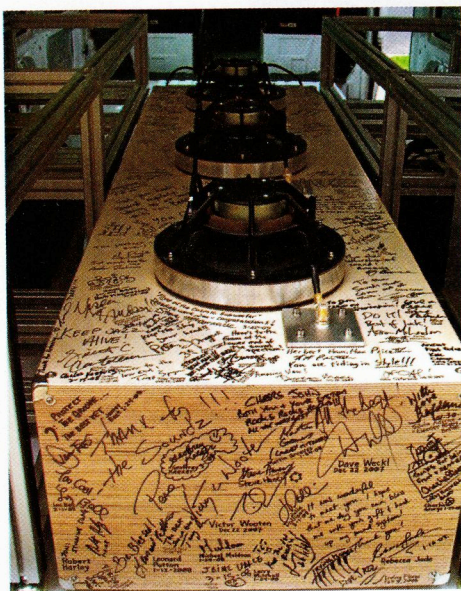
As a reader of *The Absolute Sound*, you are no doubt a lover of music, and a lover of the technology that reproduces music. I too, am a lover of all things music- and audio-related. I particularly enjoy jazz and classical performances, and routinely attend live shows at various venues throughout San Diego's vibrant musical scene. I tend to enjoy more intimate shows, where members of the audience can sit as close as a few feet from the performers. No other experience helps me calibrate my ears to the reality of live sound, to better understand ways to



further improve my home listening experience. As an added benefit, I've met many of the wonderful musicians after their shows.

Several years ago, I owned a VW camper van in which I routinely traveled and camped throughout California. I often longed for an audio system in my car that approached the level of sound I was accustomed to hearing. But as a home audiophile, my standards were high, and I felt that all of the mobile audio systems I'd heard just didn't have the realism I was seeking. That all changed when I visited North County Mobile Electronics on one fateful day. It was there that I heard the Dynaudio System 360 speakers, powered by McIntosh electronics, and I knew those were the components I must have. So I bought a complete system and did the installation myself. Although I built the system purely for personal enjoyment, I decided, on a whim, to enter a local sound-quality competition. Not only did I win first-place at that competition, but also at the next ten competitions I entered. Eventually, an article about my VW camper van appeared in *Car Audio and Electronics* magazine.

Even though I still enjoyed my high-end home audio system, (which served as my reference for developing the system in my VW van), I was also thoroughly enjoying my mobile audio system. I found that as I became more pressed for time, it was increasingly difficult to sit down and listen to my home audio rig, and the solitude of my car became one of the only places where I could enjoy music to its fullest. My car audio system provided me with relief from life's madness, and turned my car into a refuge, a place where life's problems melted away as I turned up the volume, relaxed, and got lost in the music.



The subwoofer enclosure is built from 2.83"-thick Baltic Birch ply. Note the many autographs of world-famous musicians who have heard the Magic Bus.

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The drive (pun intended) to make something better is at the core of high-end audio. Although the audio system in my VW was extraordinary, I dreamed of what was possible if the principles of high-end home audio were applied to the automobile in a way that I hadn't seen done before. As a polymer scientist and mechanical engineer, I knew it would be necessary to avoid limitations common to car audio systems, and throw out conventional approaches and thinking. I felt the possibilities in mobile audio were essentially unbounded, limited only by my imagination and craftsmanship skills. Intrigued by this concept, I set out to design and build a "no holds barred" automotive audio system capable of being compared to the finest home audio systems. I felt the best way to achieve this, logically, was to use as many high-end home products as possible, adapted to my application. After a great deal of research, I chose the finest components available from manufacturers whose products exemplify quality and passion for audio, such as those from Dynaudio (loudspeaker transducers), Kimber Kable (interconnects and speaker cable), WBT (audio connections), Genesis (amplifiers), Cascade Audio Engineering (sound damping and room treatments), and Alpine (digital source and processor).

As many audiophiles have learned, regardless of the absolute quality of the components, the sonic characteristics of the listening room dramatically influence the performance of the playback system. Since it's best to start "from scratch" with a dedicated listening room, I chose the vehicle with great care, thoroughly researching the influence of cockpit geometry, loudspeaker placement, system layout, and interior dimensions in order to provide the system with a "room" affording the greatest potential for accurate playback. Considering the internal volume, distribution of axial resonance modes, and reverberation times for several types of vehicles, I concluded that a Mercedes-built Dodge Sprinter 3500 SHC ("Super High Ceiling") van was optimum. The high roof of the van permitted the majority of the



View of overhead electronics console (cosmetically unfinished) with headliner removed.



left: The front monitors are housed in custom enclosures. above: The door panels were built from scratch to house the lower-midrange driver (cosmetically unfinished).

RH Listens to the Magic Bus

I must say that I wasn't overly enthusiastic about listening to Jon Whitledge's van; such systems tend to be demonstrated at hearing-damaging levels, and attempt to impress with sheer sound-pressure level rather than audiophile criteria such as soundstaging, detail resolution, and naturalness of timbre. Nonetheless, I was intrigued after hearing about the system's extraordinary design and execution.

I'm glad I put my prejudices aside, because listening to Jon Whitledge's Magic Bus was a revelatory experience. Sitting in the driver's seat with my portable CD case, I played one familiar reference disc after another. For starters, the system was extremely smooth and well balanced tonally. The treble didn't exhibit the hyped metallic sound so often heard in cars, and the midrange had a richness of tone color that gave instruments and voices a real sense of body.

What really floored me, however, was the system's ability to create a three-dimensional soundstage in front of me. It was like sitting down between a pair of well set up loudspeakers in a room. Despite sitting far off axis in the driver's seat, the soundstage was perfectly symmetrical, with depth and layering that were extraordinary. Listening to Rutter's Requiem produced a startling sense of disconnect; the soundstage extended far in front of the windshield, with every instrument perfectly positioned and proportioned. The illusion of pinpoint images, surrounded by an expansive acoustic, was outstanding even by home-audio standards.

The bass was fabulous in many respects: pitch definition, extension, dynamics, and the ability to play loudly without strain. Kick drum was taut, punchy, and tight, with no sense of slowness or overhang. Moreover, the bottom end, reproduced by enormous bass cabinets in the van's cargo area, blended seamlessly with the midrange and treble drivers located in front of the listener.

The Magic Bus sounded like a high-end home system—and a very good one at that.

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audio system's componentry to be mounted up front on an overhead console. This also allowed the use of the shortest possible interconnects and loudspeaker cables, a common goal of home audiophiles.

Within the realm of automotive audio, there are only a few digital front ends considered to be truly of "audiophile quality." The very best among them is Alpine's DVI-9990 DVD Audio/Video Tuner and companion PXI-H990 Multimedia Manager (sadly, Alpine has since discontinued these products). These extraordinary components communicate with one another using noise-immune digital cables, which keep the musical information in the digital domain until just before amplification. The PXI-H990 was equipped with eight analog outputs, six of which were used for the front soundstage, and two of which were used for the subwoofer. The remarkable digital signal processing (DSP) capabilities of Alpine's PXI-H990 provided an extraordinary level of control over each of the loudspeakers. The versatile interface of the DVI-9990 allowed each of the eight analog outputs to be programmed in the digital domain. Adjustments including level (± 9 dB), crossover frequency, low-pass and high-pass crossover slopes (6, 12, 18, 24, or 30 dB/octave), phase (0 or 180°), and time delay (± 50 microsecond resolution) were available for each of the eight channels. In addition, 31 bands of equalization were available for each of the left and right channels as well as 10 bands of equalization for each of the two subwoofer channels. Parametric equalization was also available. This remarkable level of control over each of the loudspeakers allowed me to tune the system to achieve a balanced soundstage, even for asymmetric listening.

For many reasons, particularly for achieving appropriate soundstage height, I believed the best place for tweeters and midranges was above the dash. Any other location puts objects (driver's legs or arms, center consoles, dashes, and the like) in the path of the direct sound to the listener. These objects absorb, reflect, or refract sound, which I believed would interfere with proper tonal balance and imaging. The Sprinter van is one of the few vehicles that can feasibly accommodate midrange transducers above the dash, in appropriately sized sealed enclosures, without appreciably obstructing the driver's view through the windshield or the rear-view mirrors. For loudspeaker transducers, I chose Dynaudio's MD130 tweeters and MW150 midranges. The tweeter and midrange pair were mounted on a 1/4" (6.35mm) CNC-machined steel plate, which was screwed to the 1-1/4" (31.8mm) thick enclosure, sandwiching a 1/8" (3.2mm) thick Sorbothane gasket, which functioned as a constrained damping layer. The enclosure was fabricated from MDF and fiberglass composite, and was mounted and isolated in such a way that it "floated" above the dash and away from the windshield to avoid the transmission of vibrations to and from those structures. The bare enclosures each weighed 24 pounds and were heavily damped with Cascade Audio's products. The mounting base of each enclosure

was machined from 1/4" aluminum into which four WBT binding posts were mounted. A clever arrangement of WBT's spades and banana plugs was used to connect the speaker cables, which were custom made from Kimber Kable's 4TC bulk speaker cable. Each transducer received its own channel of DSP and 150W of amplification. Thus, the front monitors both received a total of 600W of power, provided by two Genesis Dual Mono amplifiers. The enclosures were gently contoured to minimize diffraction. During the fabrication process, I evaluated the imaging of the non-optimally-contoured monitors, but I was stunned when I heard the sonic benefits of reduced diffraction with properly contoured enclosures. I spent months fine-tuning the aim of these monitors to achieve the best balance between center image focus and stage width, and months finishing these enclosures to auto-body-quality standards. The magnetically attachable grilles were designed mainly for protective purposes, and consequently critical listening is done with the grilles removed.

To appropriately anchor the front soundstage and to minimize the localization of the subwoofer, I wanted the front woofers to deliver as much of the low-frequency spectrum as possible. This necessitated the use of large drivers in the front cockpit area. For the Sprinter van, the only viable locations for these were the doors. Luckily, this placement, relative to the midrange transducers, positioned the acoustical centers among the transducers within reasonable physical alignment. The use of Dynaudio's MW180 loudspeaker transducers was nearly optimal, owing to their low-profile depth, low resonant frequency, and excellent sealed box performance. Given an automobile door's propensity to rattle and vibrate, I believed the use of a sealed enclosure, rubber-isolated from the door, would provide the best performance. Because of the sealed enclosure's required volume, custom door panels were required. The door panels were completely isolated from the sealed enclosures. Every step of the design and fabrication process for the enclosures and door panels focused on increasing rigidity, reducing or eliminating mechanical and acoustical resonances, and maximizing the damping of the structures. I used Cascade Audio's Deflex Power Pads inside each of the enclosures to damp the loudspeaker transducer's back-wave reflections, and I coated the internal and external surfaces of the enclosures with Cascade Audio's VB-1X damping compound. The bare door enclosures, for example, each weighed about 35 pounds, and each of the door panels weighed about 15 pounds. Each loudspeaker transducer received its own channel of DSP and 325W of amplification. Thus, the front door loudspeakers both received a total of 650W of power provided by one Genesis Dual Mono Xtreme amplifier.

I believe my subwoofer design is unique among subwoofers in the automotive audio industry. First and foremost among my design goals was to create an enclosure as rigid and free from resonances as possible. To accomplish

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this, the subwoofer enclosure was laminated from 18 layers of 18mm (0.71 inch) thick Baltic Birch plywood in such a manner that the wall thickness of the enclosure was 72mm (2.83 inches) thick. Dynaudio's MW190 transducers were configured in three isobaric pairs for two reasons. First, the enclosure volume was reduced by half. Second, odd-order non-linearities (however insignificant they may be with such a finely engineered transducer) were effectively cancelled, resulting in substantially reduced driver distortion. I preferred the use of sealed enclosures to reduce low-frequency roll-off, improve transient response, and minimize group delay. The transducers were wired in a series-parallel combination to achieve a nominal impedance of about 2.53 ohms. The Genesis Dual Mono Xtreme amplifier received left and right channel signals discretely, but summed them to mono, and delivered in excess of 1kW to the transducers. The entire subwoofer system weighed well over 300 pounds and was mounted on military-grade, fail-safe rubber vibration isolators with a natural frequency tuned to 11Hz, effectively decoupling the enclosure vibrations from the body of the van. The subwoofer was wired with custom-made Kimber Kable 4TC speaker cables. WBT's audio connections were used exclusively. The subwoofer was tuned to play below

its resonance frequency, an approach recommended by Steve McCormack and used with great success by Richard Vandersteen. Interestingly, the effective cone area of three MW190s is essentially equivalent to the effective cone diameter of a typical commercially available 18" diameter subwoofer. But instead of using one heavy cone, I believed the lower moving mass of three lighter cones would maximize bass quality and result in exceptional integration with the front sound speakers, while at the same time delivering considerable power and bass extension. With regard to bass extension, my calculations, which included room gain, estimated the output of the subwoofer to be 115dB at 20Hz, with considerable output below 20Hz.

I'm quite pleased with the sonic outcome of my system, and so are many others. I've received numerous compliments regarding the sound quality from home audiophiles, mobile audiophiles, recording engineers, and musicians. I invite the readers of TAS to visit my Web site at whitledge.com to learn more about my van and the services Whitledge Designs provides. I would like to thank Robert Harley for auditioning my van, a labor of love that is still not finished even after an investment of more than 4000 hours of labor over the course of better than three years. **TAS**

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