15M is built on a proprietary six-spoke cast aluminum frame that minimizes reflections off the frame back into the cone. Significant cooling is provided by six 23 × 6 mm "windows" below the spider mounting shelf that enable air to flow across the frontplate and around the voice coil on forward excursions. Powering this 5.25" device is a conventional 15-mm thick 85-mm diameter ferrite magnet, sandwiched between the polished frontplate and rear T-yoke. The T-yoke also has a 7-mm diameter pole vent. Other features include a NRSC fiber glass curvilinear cone with a light damping coating on the back, rubber coated 1"-diameter phase attached to the pole piece, a very low-damping black foam surround, 3"-diameter black flat cloth spider, 1" (25 mm) diameter voice coil (aluminum former wound with round copper wire), an aluminum shorting ring (Faraday Shield), and gold-plated terminals.

Testing commenced with the driver clamped to a rigid test fixture in free-air, voltage, and current sweeps taken at 0.3 V, 1 V, 3 V, and 6 V. Since this is a small diameter driver with the short Xmax of a mid-range (1.5 mm), I was surprised that the 6-V data was not too nonlinear for LEAP 5 to curve fit. The eight 550-point stepped sine wave sweeps for each 15M mid-range sample were post-processed and the voltage curves were divided by the current curves (admittance) to create impedance curves. The phase was added using the LMS hyperbolic phase calculation method and, along with the accompanying voltage curves, uploaded to the LEAP 5 Enclosure Shop software. In addition to the LEAP 5 LTD model results, I also created a LEAP 4 TSL model set of parameters using just the 1-V free-air curves. The final data

Scan-Speak's 15M/4624G00

Moving on to the 5.25"-diameter 15M/4624G00, this driver represents the mid-range addition to the relatively recent and cost-efficient Scan-Speak Discovery line (see **Photo 3**). Small-diameter mid-range drivers used in three-way designs have always been an important product for Scan-Speak. The

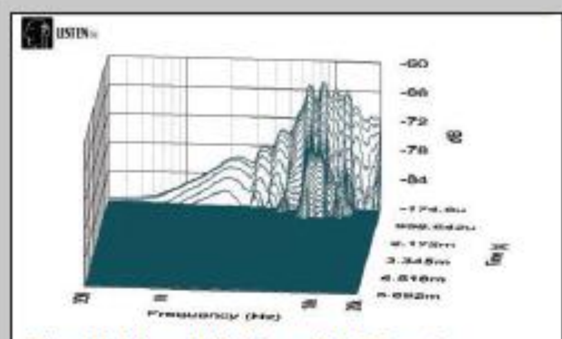

Figure 14: Airborne RT-4101 SoundMap CSD graph

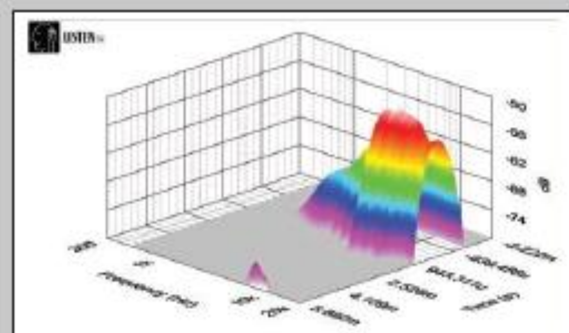

Figure 15: Airborne RT-4101 SoundMap STFT plot

Photo 3: Scan-Speak's 15M/4624G00 mid-range driver

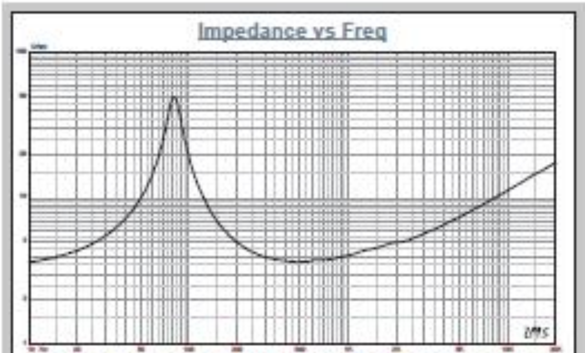

Figure 16: Scan-Speak 15M/4624G00 free-air impedance plot

set, which includes the multiple voltage impedance curves for the LTD model (see **Figure 16** for the 1-V free-air impedance curve) and the 1-V impedance curve for the TSL model, were selected and the parameters were created to perform the computer box simulations. **Table 1** compares the LEAP 5 LTD and TSL data and factory parameters for both of Scan-Speak 4" samples.

Unfortunately, the LEAP parameter calculation results for the Scan 15M mid-range didn't correlate well with the factory data, with the factory data having a significantly higher Fs, a lower Vas, and higher sensitivity. I've found that published data isn't always updated throughout production, so sometimes this happens. Given the overall level of engineering integrity with Scan-Speak, I'm not too concerned about this. That said, I proceeded to set up computer enclosure simulations using the LEAP LTD parameters for Sample 1. I programmed in two sealed enclosures, one Butterworth and one Bessel response. For the first closed-box Butterworth simulation, I used a 131-ci enclosure with 50% fiberglass fill material, and for the second sealed box, a larger volume of 238ci with the same 50% fiberglass fill material.

Figure 17 displays the results for the Scan-Speak 15M/4624G00 in the two sealed boxes at 2.83 V and at a voltage level sufficiently high enough to increase cone excursion to Xmax + 15% (1.7 mm for the 15M). This resulted in a F3 = 144 Hz with a box/driver Qtc of 0.65 for the 131-ci closed box design and a –3 dB = 117 Hz and a Qtc = 0.55 for the 238-ci sealed box simulation. I conducted the two sealed

	TSL model		LTD model		Factory
	sample 1	sample 2	sample 1	sample 2	
Fs	80.5 Hz	75.3 Hz	77.2 Hz	72.4 Hz	100 Hz
Revc	3.14	3.14	3.14	3.14	3.2
Sd	0.0080	0.0080	0.0080	0.0080	0.0080
Qms	5.83	5.57	5.67	6.03	5.62
Qes	0.38	0.34	0.40	0.39	0.47
Qts	0.36	0.33	0.38	0.37	0.43
Vas	5.7 ltr	6.6 ltr	6.3 ltr	7.2 ltr	3.7 ltr
SPL 2.83 V	90.8 dB	91.0 dB	90.4 dB	90.3 dB	92.4 dB
Xmax	1.5 mm	1.5 mm	1.5 mm	1.5 mm	1.5 mm

Table 1: Scan-Speak 15M/4624G00 mid-range driver

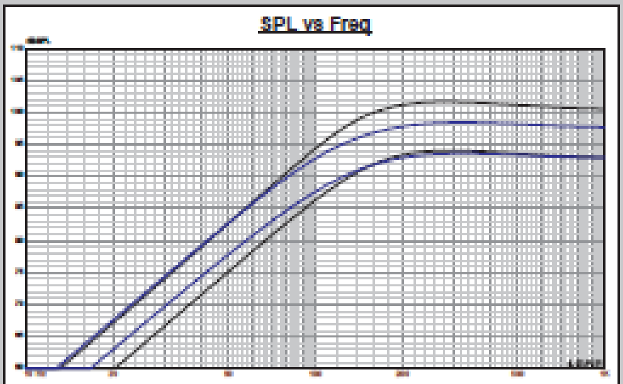

Figure 17: Scan-Speak's 15M/4624G00 computer box simulations (black solid = sealed 1 @ 2.83 V; blue dash = sealed 2 @ 2.83 V; black solid = sealed 1 @ 7 V; blue dash = sealed 2 @ 6 V)

simulations because the Butterworth enclosure was almost too small to be practical, plus making the enclosure larger lowers the resonance enough to make designing a high-pass network less of a problem.

Increasing the voltage input to the simulations until the maximum linear cone excursion was reached generated a surprising (for a mid-range with no high-pass filter) 102 dB at 7 V for

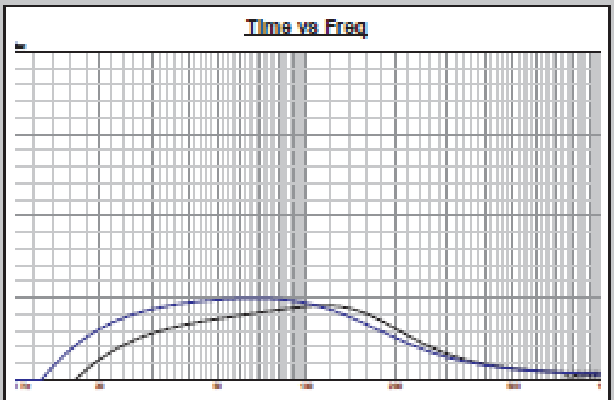

Figure 18: Group delay curves for the 2.83-V curves in Figure 17

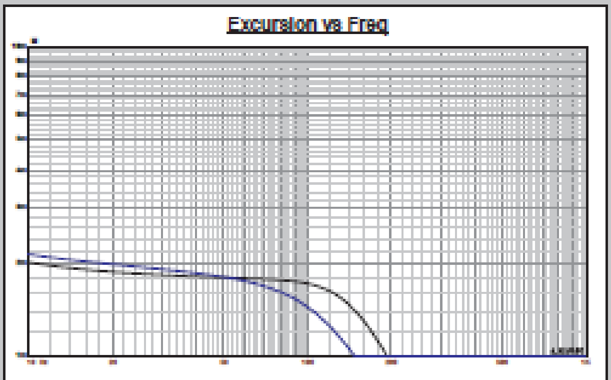

Figure 19: Cone excursion curves for the 7/6-V curves in Figure 17

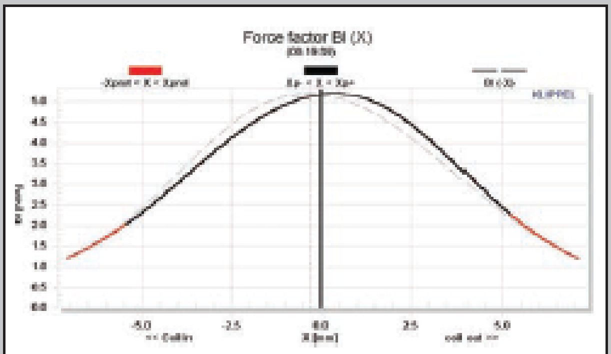

Figure 20: Klippel analyzer Bl (X) curve for the Scan-Speak 15M/4624G00

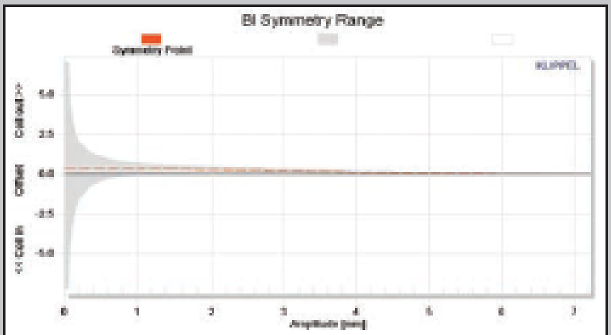

Figure 21: Klippel analyzer Bl symmetry range curve for the Scan-Speak 15M/4624G00

the smaller sealed enclosure simulation and 98.5 dB with a 5-V input level for the larger sealed enclosure. See **Figure 18** and **Figure 19** for the 2.83-V group delay curves and the 7/5-V excursion curves. Very reasonable performance for a 5.25" mid-range given this was "wide open" without the high-pass filter that will always be used with this product.

Klippel analysis for the Scan 15M mid-range driver produced the Bl(X), Kms(X), Bl, and Kms symmetry range plots given in **Figures 20–23**. The Bl(X) curve for the 15M (see **Figure 20**) is somewhat narrow and symmetrical, typical of short Xmax drivers, with a trivial coil-out (outward) offset. Looking at the Bl symmetry range curve in **Figure 21**, there is a 0.4-mm coil-out (forward) offset that goes to 0.3 mm at the physical Xmax position (1.5 mm for the 15M), so very nice. **Figure 22** and **Figure 23** give the Kms(X) and Kms symmetry range curves for the 5.25" mid-range. The Kms(X) curve is even more symmetrical. Figure 23 shows a 0.15-mm coil-out offset at the rest position that decreases to 0.09 mm at the physical Xmax of the driver. Displacement-limiting numbers calculated by the Klippel analyzer for the Scan-Speak mid-range were XBl @ 82% Bl = 2.3 mm and for XC @ 75% Cms minimum was 3.6 mm, which means that for this 5.25" mid-range driver, the Bl offset is the most limiting factor for a prescribed distortion level of 10%, but both numbers are significantly beyond Xmax.

Figure 24 gives the inductance curves L(X) for the 15M/4624G00, which shows the inductance decreases as voice coil travels inward covering more of the pole piece, typical of a driver with a shorting ring installed—it is aluminum in the case of the 15M mid-range. The inductance swing from Xmax forward to Xmax rearward is about 0.16-to-0.17-mH inductance, which is excellent.

With the Klippel testing complete, I mounted the 15M midrange in an enclosure that had a 15" × 5" baffle filled with foam damping material and proceeded to measure the driver

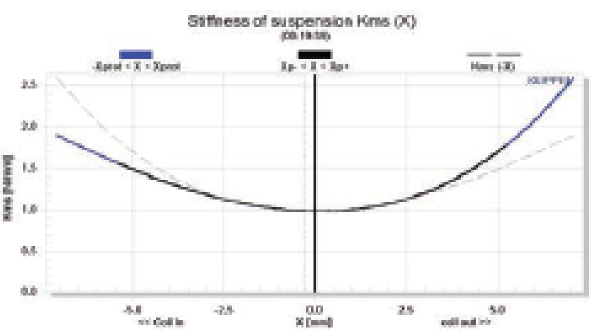

Figure 22: Klippel analyzer mechanical stiffness of suspension Kms (X) curve for the Scan-Speak 15M/4624G00

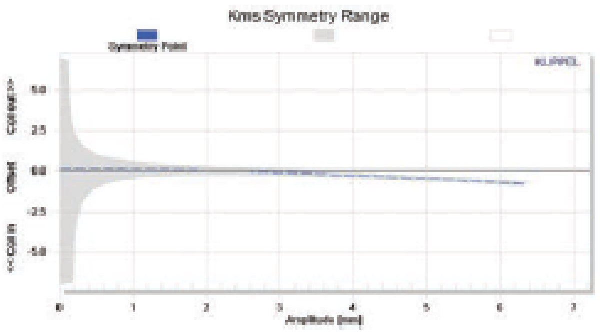

Figure 23: Klippel analyzer Kms symmetry range curve for the Scan-Speak 15M/4624G00

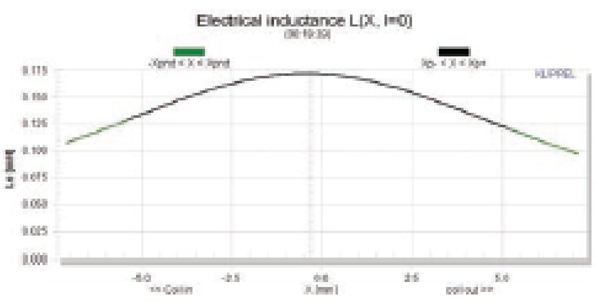

Figure 24: Klippel analyzer Le(X) curve for the Scan-Speak 15M/4624G00

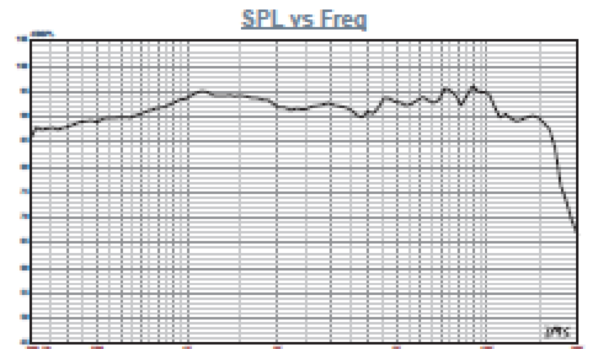

Figure 25: Scan-Speak 15M/4624G00 on-axis frequency response

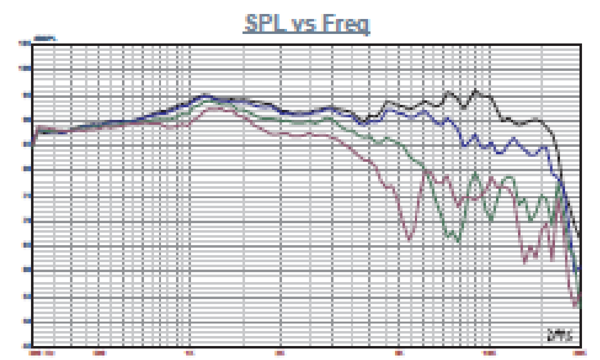

Figure 26: Scan-Speak 15M/4624G00 on- and off-axis frequency response (0° = black, 15° = blue, 30° = green, 45° = purple)

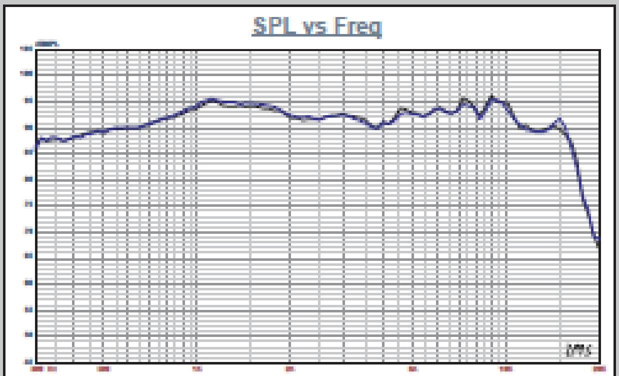

Figure 27: Scan-Speak 15M/4624G00 two-sample SPL comparison

frequency response both on- and off-axis from 300 Hz to 40 kHz at 2.83 V/1 m using a 100-point gated sine wave sweep. **Figure 25** shows the 15M's on-axis response, resulting in a very flat rising response that is ±1.68 dB from 300 Hz to 4.5 kHz with a small peak just before the low-pass roll off. **Figure 26** has the on- and off-axis frequency response at 0°, 15°, 30° and 45°. A 3-to-4.5-kHz crossover frequency would be appropriate for this Scan-Speak small woofer because –3 dB at 30° with respect to the on-axis curve occurs at 4.5 kHz. **Figure 27** gives the two-sample SPL comparisons for the 5.25" 15M driver, showing a good match within the 15M's operating range.

For the last group of testing, I again fired up the SoundCheck analyzer, the SCM microphone, and power supply to measure distortion and generate time frequency plots. Setting up for the distortion measurement consisted of mounting the woofer rigidly in free air, and setting the SPL to 94 dB at 1 m (1.16 V) using a pink noise stimulus. (Two of SoundCheck's utilities are a software generator and SPL meter.) The distortion was measured with the SCM microphone placed 10 cm from the dust cap. This produced the distortion curves shown in **Figure 28**.

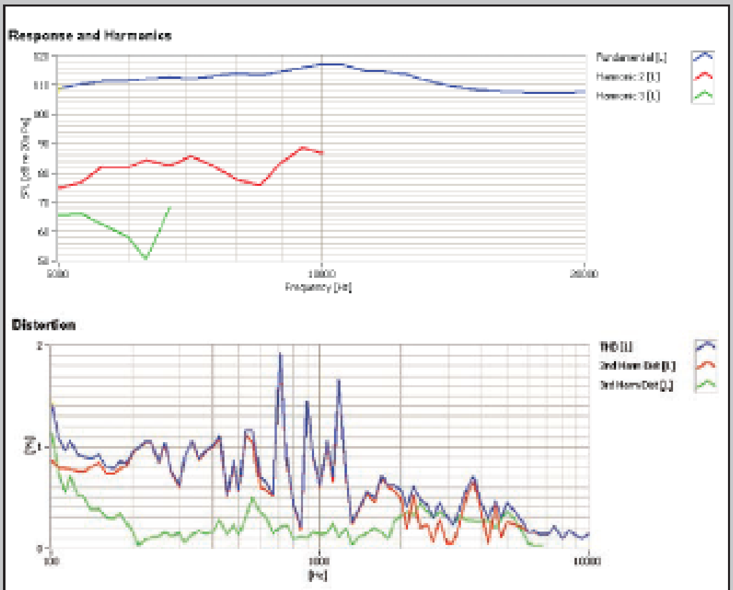

Figure 28: Scan-Speak 15M/4624G00 SoundCheck distortion plots

For the last test on the Scan 15M, I used the SoundCheck analyzer to get a 2.83-V/1-m impulse response for this driver and imported the data into Listen, Inc.'s SoundMap Time/Frequency software. The resulting CSD waterfall plot is shown in **Figure 29** and the Wigner-Ville (for its better low-frequency performance) plot is shown in **Figure 30**. Visit the Scan-Speak website at www.scan-speak.dk for more information. ***VC***

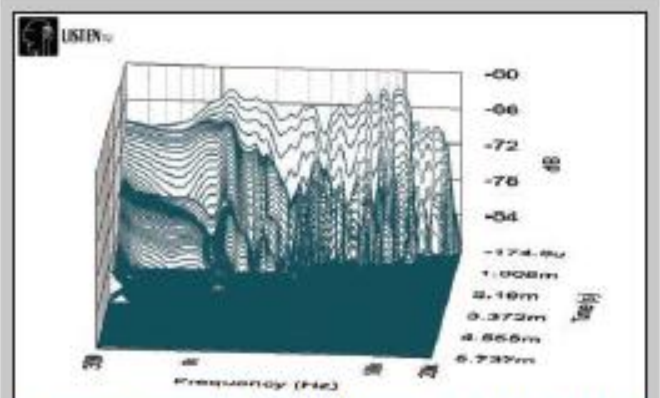

Figure 29: Scan-Speak 15M/4624G00 SoundCheck CSD Waterfall plot

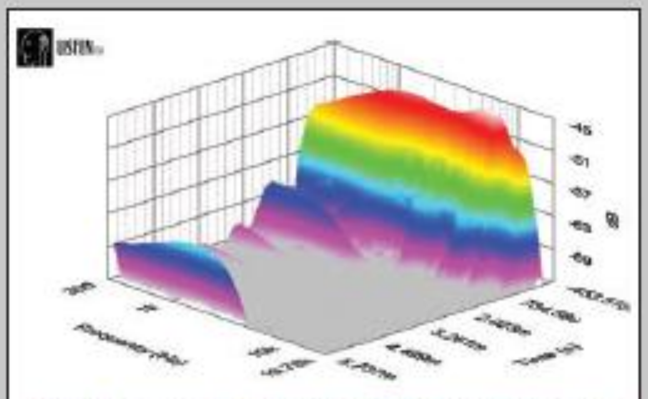

Figure 30: Scan-Speak 15M/4624G00 SoundCheck Wigner-Ville plot