The “Infinite” Baffle Loudspeaker

10-01-2005

Update 06-08-2005

Acapella WB

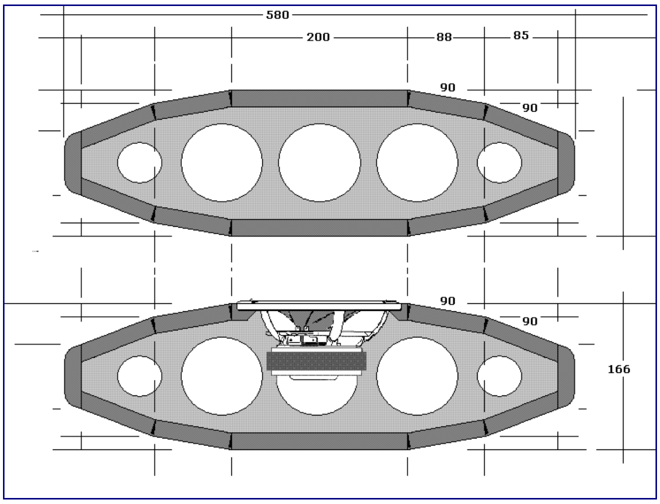

Figure 1

One loudspeaker construction leads to the next. No revolution, just evolution. We still employ technology and materials developed decades ago. Paper pulp, plastic and metal cones, ribbons and electrostatic panels - ceramic drivers are new in this context. And we have to surround the drivers with some kind of enclosure to eliminate rear wave cancellation in order to produce decent bass response. Closed and vented boxes, transmission lines and horns.
Working on dipoles - or semi-dipoles - was a new entry to my hobby and it took my plans into a new direction. Having lived with my semi-dipoles for more than a year, I have a hard time adjusting to any "boxy" sound again. The midrange sounds constrained with limited soundstage and articulation. The obvious next step would be the dipole bass and I probably will try this some time, but I've had my share of electronic crossovers and multiple amps in the past and for the time being I want to keep things fairly simple: one amp and a pair of speakers with passive crossovers.

What has been argued against wide baffled speakers is some loss of pinpoint imaging and this may be true.

Mr. José Victor Henriques from his review of the new Sonus Faber Stradivari speaker:
"The Stradivari sounded like a live performance in a real venue, filling the room with sound and doing the proverbial vanishing act. Maybe less so because you just couldn't take your eyes off them. Given the larger than usual baffle, focus is not to the pin-point accuracy standard of, say, the Wilson Watts Puppies (their natural competition in this price range), suggesting some attention to “toe-in” to further sweeten the "spot". On the other hand I must confess I've never heard live “pin-point focus” as the instruments and singers usually energize the air around them creating a “bubble” of sound not just an “ideal” point source. In this particular aspect of sound reproduction, the Stradivari is closer to reality".

"Live pin-point focus": Has high-end HI-FI forgotten something here? The trend in recent years has been towards speakers with very narrow front baffles, trying to eliminate reflecting surfaces around the drivers, presumably enhancing pinpoint imaging. And with apparent commercial success. What is the trade-off? Because there's always a trade-off in speaker building. Well, by having a very narrow front baffle we will have edge diffraction at a rather high frequency giving delayed response subtracting from the target of pin-point imaging. We all know that a round sphere is the ideal surrounding for a speaker but for large drivers the sphere has to be large, very large and the WAF is close to zero. We never saw a commercial success from a sphere shaped speaker where the very narrow and slim line speakers can be rather deep (to give volume) and still appear smallish = high WAF.

Paul Messenger:
"Narrow speakers with a very wide radiation include more of the listening room and help create an illusion of bringing the musicians into the room; while more directional designs like horns and dipole panels give a precise view onto the recording itself. Neither one nor the other, the Stradivari is perhaps the ideal compromise between the two."

With narrow baffles we also run into serious baffle step compensation issues and we have to apply large inductors to the basic driver in order to tilt the frequency response to be flat. Large inductors = large phase shifts. With a wide baffle the need for large inductors are reduced as we are dealing with a virtual 2pi situation. The "almost-infinite" baffle.

Henriques again:
"The virtual 2 pi radiating infinite baffle is based on the concept/surface of the “piano armonico” of the violin which allows the midrange unit to reach its lower frequency limit in a more poised and natural

way, thus conveying to the listener a sense of better integration with the massive double bass drive units".

Roy Allison (former Acoustic Research and Allison Loudspeakers) in Stereophile, Jan/05) on the development of the Allison Model-1:
"I had emphasized dispersion in order to re-create as best as I could the performance-hall ambiance. I don't want to put up with a sweet spot, and I'd rather have a less dramatically precise imaging with a close simulation of what you hear in a concert hall in terms of involvement. For that, you need reverberant energy broadcast at very wide angles from the loudspeaker, so the bulk of energy has to do multiple reflections before reaching your ear. I think pin-point imaging has to do with synthetically generated music, not acoustic music - except perhaps for a solo instrument or a solo voice, where you might want fairly sharp localization. For involvement, you need widespread energy generation."
With a 66 cm wide baffle the Stradivari mid-drivers hardly need any baffle step compensation. It will basically be flat down to 200-300 Hz. (See the P13 driver in the "dipole study" at:
http://www.troelsgravesen.dk/OBS.htm

The experiences gained from the Point75, the Acapella LT95, the Acapella LWJ/SE and last but not least from reading about the newest creation from Sonus Faber, the Stradivari, lead to the idea of combining the midrange dipole with some look-alike Stradivari bodywork. To call this construction an infinite baffle is a truth with some modifications. Having an infinite baffle would mean mounting the drivers on a wall, creating a true 2pi environment.
By making a wide and curved baffle cabinet, edge diffraction is avoided and a virtual 2pi radiation pattern is produced. Any driver mounted on a baffle will have an f3 = 11,600/width of baffle in cm. A driver mounted on a baffle of 20 cm with will be down 3 dB at 11,600/20 = 580 Hz. Making the baffle 50 cm wide the f3 is reduced to 232 Hz. Enough for a midrange driver working from 300-400 Hz to release its full potential without baffle step compensation. To read more about baffle step compensation and cabinet edge diffraction, try the following links:
http://sound.westhost.com/bafflestep.htm#bafflestepresponse
http://www.t-linespeakers.org/tech/bafflestep/index.html
http://www.speakerdesign.net/understand.html
http://www.silcom.com/~aludwig/images/difdemo.gif

Ken Kessler writes in his report on the Stradivari that it sounds like a dipole, so whether the midrange here will have to work as a true dipole is to be seen. Prototype baffles will have to be flexible to accommodate both vented midrange boxes and dipole arrangements. The sketches shown here are purely made to start thinking in curved, wide baffled constructions. No dimensions or calculations at this stage. A truly curved front panel is not an easy task and will probably require gluing several layers of thin MDF sheets over curved internal bracing. The prototypes are likely to resemble what is seen from the sketches.

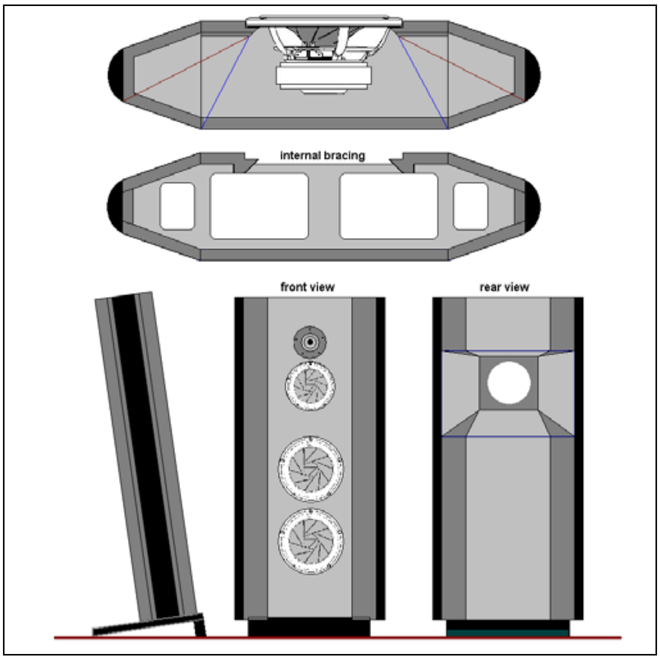

Figure 2

A few words on the Sonus Faber cabinet philosophy. Linking cabinet work to the famous Italian violinmakers is indeed very clever from a marketing perspective. It creates a positive feeling and you may think some of the mystery of the ancient Stradivarius violins is build into the products. And there's not a dry eye around after having heard about exotic woods and ancient varnishes made from secret recipes. Obviously this is marketing rubbish. I have no doubt that Sonus Faber has done a great job in creating cabinets with decent bracing, laminated panels and with low colouration as a result. The overall finish is exquisite and the result is truly beautiful loudspeakers. Well done indeed. But exotic woods will not necessarily create acoustically optimal loudspeaker enclosures. Laminating solid wood and MDF/HDF may give good results but no matter what we do, the target is nothing more than an acoustically dead cabinet. And this can be accomplished in numerous ways. The worst argument against MDF I have seen was from a constructor who claimed that MDF was completely inferior for loudspeaker cabinets, the argument being: "Have you ever seen a piano made from MDF?"
Well, well, well. At least some of the wood in a piano is very much supposed to resonate. In any acoustic instrument the instrument body is supposed to vibrate/resonate and add to the overall sound, where the "body" holding a loudspeaker is supposed to act as a rock-solid, non-resonating support giving us the possibility of hearing what comes from the driver membrane and nothing else. Besides a sturdy driver support we want the cabinet to provide the acoustic environment chosen for our driver, being a narrow or wide baffle. If we think of modern loudspeakers

sounding dead and uninspiring we better take a look at the drivers used and compare them to the old drivers with paper cones, high Qm, etc. They may hold some qualities we miss today - but not all - and the cabs are usually not something to go back to unless we are talking sand-filled sandwich constructions.

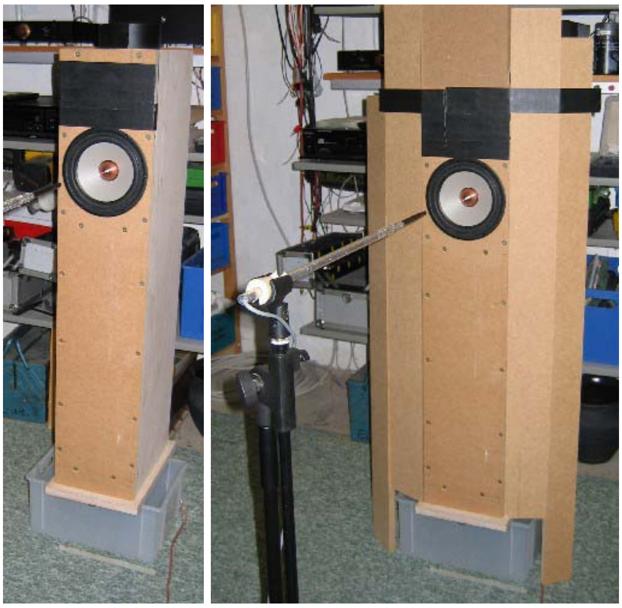

Figure 3.

TJL cabinet used for initial measurements.

The images above depict the TJL cabinet used for initial experiments. To the left the TJL cab with the ribbon masked off by tape. To the right sheets of MDF have been added to give and overall width of approx. 50 cm. The side baffles are angled to give a slightly curved front baffle.

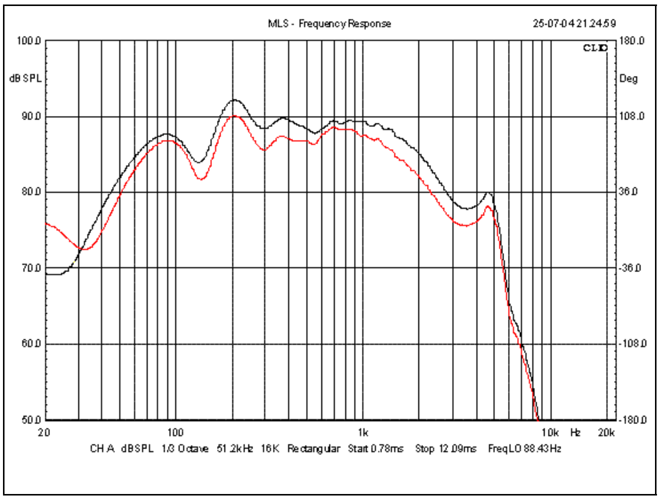

Figure 4.

Red = narrow baffle. Black = wide baffle.
A simple 2nd order filter is applied to the driver in order to create a flat midrange response.
Red: 1.8 mH/9 uF. Black: 1.2 mH/10 uF.

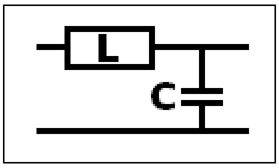

Figure 5.

So, what has happened here is that by applying a simple set of side panels we get an overall 1½-2 dB higher sensitivity and we can substitute the 1.8 mH coil with a 1.2 mH coil to achieve the same frequency response profile.
The microphone is placed 27 cm from the driver (0.78 ms) and the signal stops at 12 ms = 413 cm, so a lot of room reflections are included in this reading. I would have expected the response to be almost the same below 150-200 Hz. The room used here has a severe dip around 150 Hz, so this is not due to the driver. I was surprised that the gain in amplitude appear to go all the way down and I'm not sure the picture would have looked like this had it been performed under anechoic conditions. I would like to repeat these experiments under anechoic conditions, but it's wintertime by now. Plus 2 degree centigrade outside and it's raining!
So, it may well be that the cleaver trick here is to combine room gain usually working up to around 150 Hz and the additional gain provided by the wide baffle to get an overall linear increase in system sensitivity.

Drivers:

For the wide baffle projects I have chosen to use Scan-Speak drivers and I'll use the drivers depicted below.

Figure 6. Drivers to be used in study. 18W/8531G00, 15W/4531K00, D2904/9800 and D2904/7000.

For the time being I'm working on an Acapella 3S version, an all-Scan-Speak construction using the 21W/8555-01 bass driver in a 30 litre vented/Variovent* cabinet, the 15M/4531K00 for midrange and the D2904/9800 alu tweeter. I like the sound from the 15M/4531K00 very much. It can easily go down to 300 Hz working as a dipole and it has speed and sparkle without being aggressive. Well done

Scan-Speak, making paper cones work this well is a great achievement.
My only worry with this project is that two 8 ohms drivers in parallel and 4 ohms mid-driver may produce quite low impedance in the 100-200 Hz region.

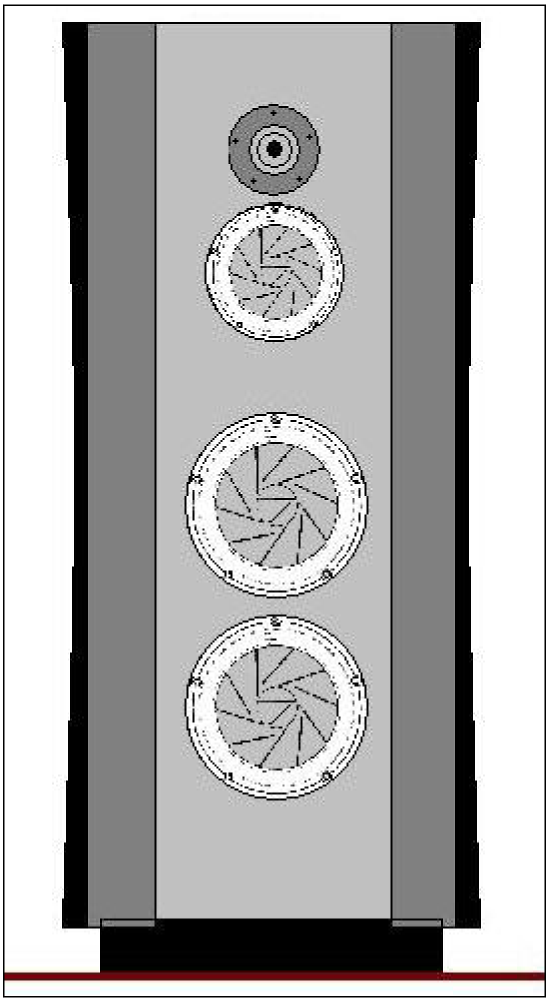

Figure 7.

*The Variovent, re-introduced by Scan-Speak, may be an option here, giving an impedance profile in the bass region that amplifiers can only dream of. But what about low-end bass and what happens to the step-response from applying Variovents?

Time to do some more basic studies:

Figure 8.

SP38 test set-up used for initial measurements, Scan-Speak 18W/8530-00 used for measurements, no filter connected.

A few words on measurements:

Some people may think that you get the truth, the whole truth and nothing but the truth whenever you place a microphone at tweeter height, at one metre distance and perform your MLS measurements. Nothing could be more wrong. Every result from the CLIO - or from whatever measuring system - only reflects the conditions chosen by the performer during the measurement. A wide range of manipulations can be added to the measurement and it can be quite difficult to keep track of all conditions adding to the final result. So, at grain of salt on every graph you're going to see here - and anywhere else for that matter.

Set-up:

- CLIOWin Standard, ISA version, is used for measurements.
- SP38/13 cabinet used with the Scan-Speak 18W/8530 driver and no crossover attached. (The 8530 is a Scan-Speak coated version of the 18W/8531G00 and to my knowledge only available in Sweden). Basically it doesn't matter what driver is used here, but I wanted a driver reasonably flat throughout the working range and this one is.
- Driver height is 100 cm above floor level.
- Height of microphone = 100 cm above floor level.
- Distance from mic to speaker is 100 cm unless otherwise stated.
- MLS measurements are performed as an average of 10 measurements.
- FFT measurements are performed as an average of 500 measurements.
- Basic cabinet width is 22 cm.
- Width of cabinet with attached baffles is 50 cm; the total width of the curved front panel is 56 cm.

First of all, what is the repeatability of the measurements from a 32 milliseconds (ms) window? With a 32 ms window the lowest reliable value is 34.1 Hz. But experience has shown this not enough.

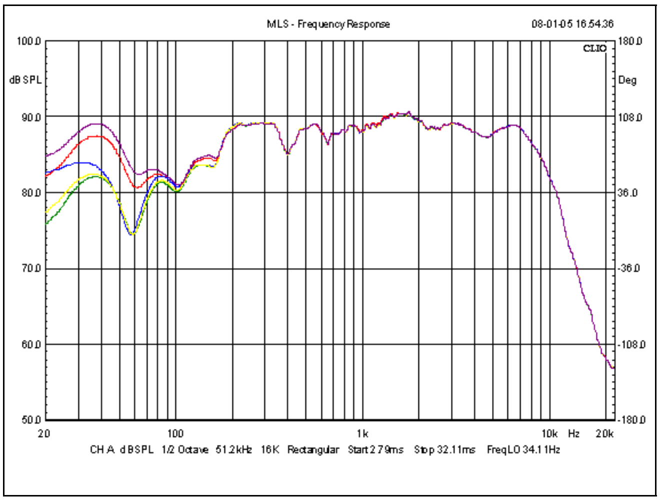

Figure 9.

Each of these five measurements is the average of 5 measurements and already at 150 Hz we have minor trouble in reproducing results. But within a 1 dB range we get a decent repeatability down to 80-100 Hz where things start being unreliable. An average of 10 MLS readings were chosen for the measurements to come.

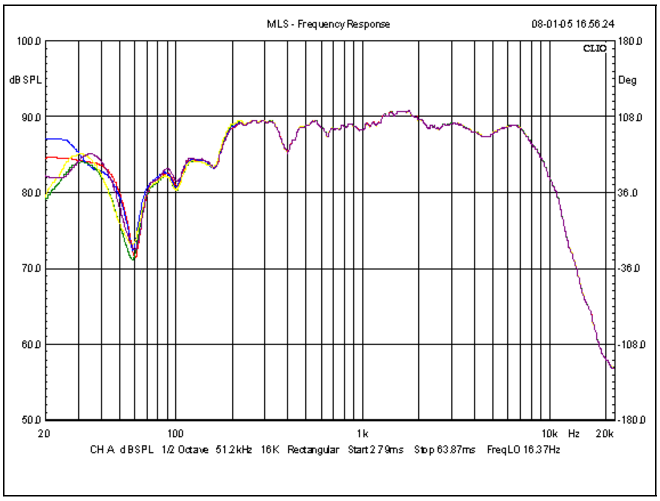

Figure 10.

Same as above with 64 ms window. This time we have good repeatability down to 50 Hz. Good enough for evaluating the baffle width.

A window of 64 ms equals a wavelength of 22 metres (344*0.064) and this is a lot. It means that what we get here is a summation of what is coming from the driver + baffle reflection and all room reflections, but not having an anechoic room doesn't leave much choice for this particular study. And we just want to learn the impact on total SPL response from applying a large front baffle. When summer is again caressing Denmark, I'll take the whole thing into the garden and repeat the measurements. It's January 2005 by now.

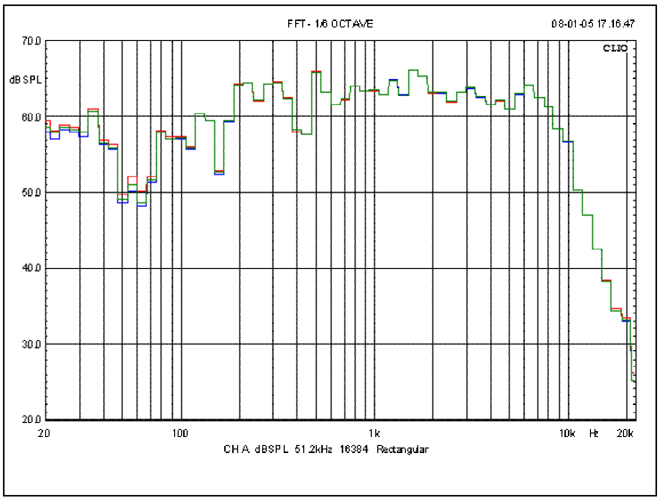

Figure 11.

Another possibility is FFT measurements, here with a resolution of 1/6 octave. Each of the three graphs is an average of 500 measurements. I had to choose 500 repetitions to reduce the standard deviation on these readings (500 repetitions takes a few seconds, so don't worry).

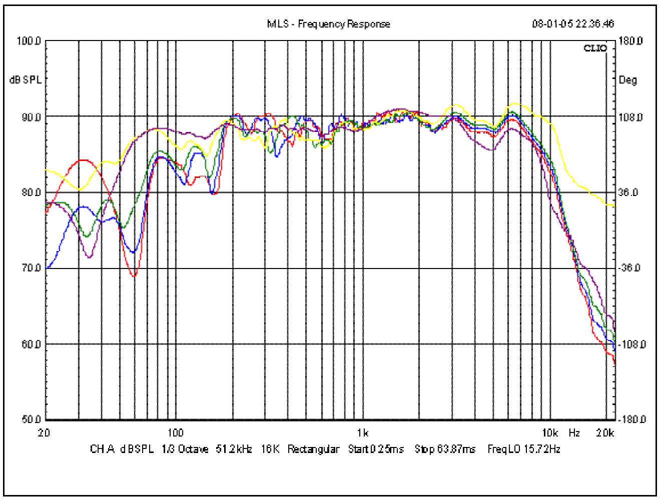

Figure 12.

Distance from microphone to driver.
Red=1m, blue=0.75m, green=0.5m, yellow=0.25m, purple=0.125m.

The input to the driver has in each case been set to target the same SPL response at 1 kHz. What can be seen is that when we reach a distance of only 0.25 metre the response below 200 Hz rises dramatically and starts looking like a near-field measurement where you place the microphone very close to the membrane. So, in the measurements to come, 1 meter has been chosen unless otherwise stated.
The initial TJL/W18E001 measurements had a decent rise in response below 200 Hz and this may be derived from only measuring at 27 cm distance.
What is to be expected from this exercise of comparing a 22 cm and a 56 (50) cm wide baffle?
A 22 cm baffle will have an F3 of (11600/22) = 527 Hz and a 50 cm baffle at (11600/50) 232 Hz. We'll see

what happens. First the horizontal dispersion will be measured and then on-axis SPL.

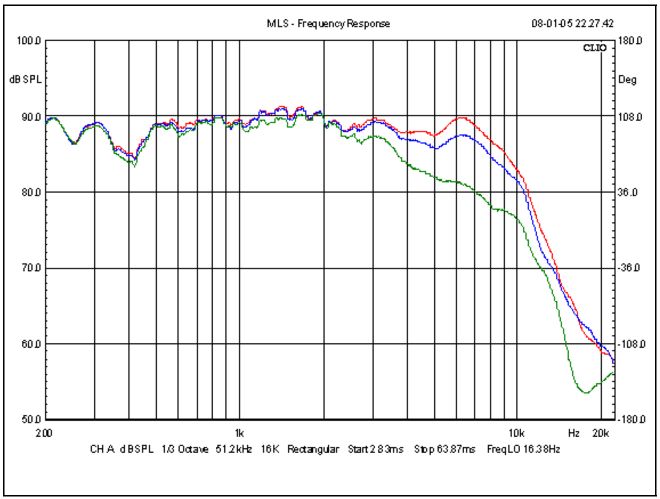

Figure 13.

Horizontal dispersion at 0, 15 and 30 deg. Baffle width = 22 cm.

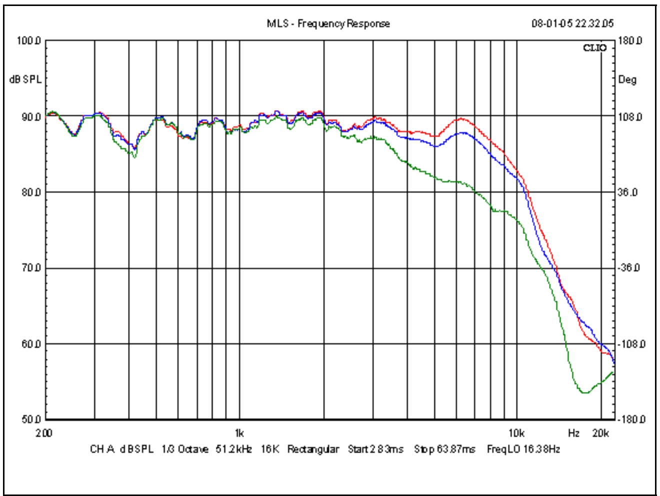

Figure 14.

Horizontal dispersion at 0, 15 and 30 deg. Baffle width = 56 cm.

As can be seen from figure 4 and 5, the additional baffles do not change the horizontal dispersion compared to the narrow baffle.

Comparing on-axis SPL measurements from 22 and 50 cm baffles:

What I want to do here is comparing the on-axis response at 1 metre distance with various gatings. And I will insert a 12 dB low-pass filter for targeting a reasonably flat response in the 300-1000 Hz region. The filters will be different due to the enhanced response in the lower midrange:
22 cm baffle: 2.2 mH (0.3 ohm)/10 uF
56 cm baffle: 1.5 mH (0.45 ohm)/16.8 uF

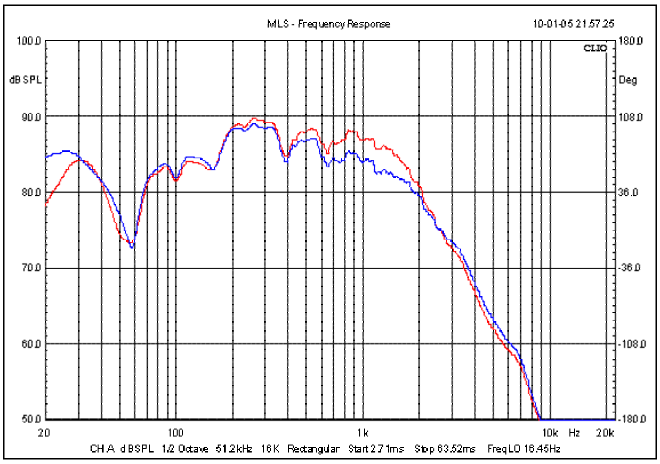

Figure 15.

64 millisecond window. Red = 56 cm baffle, blue = 22 cm baffle.

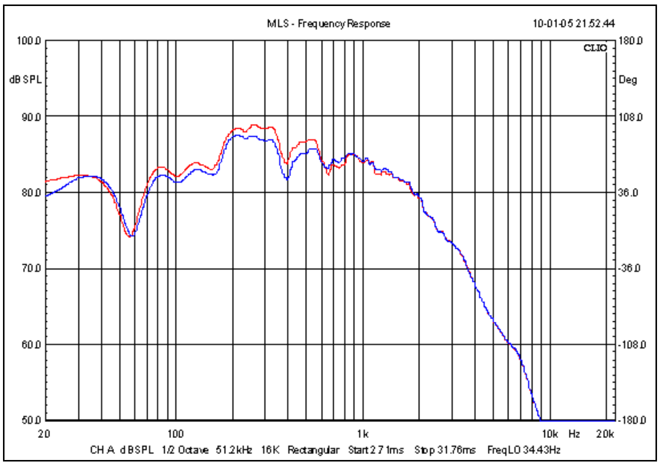

Figure 16.

32 millisecond window. Red = 56 cm baffle, blue = 22 cm baffle.

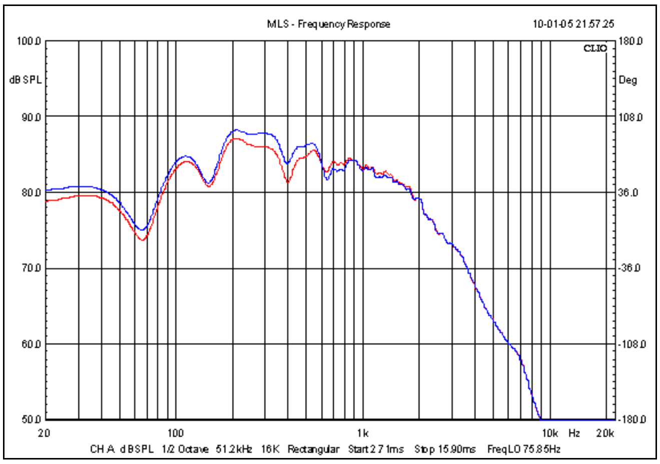

Figure 17.

16 millisecond window. Red = 56 cm baffle, blue = 22 cm baffle.

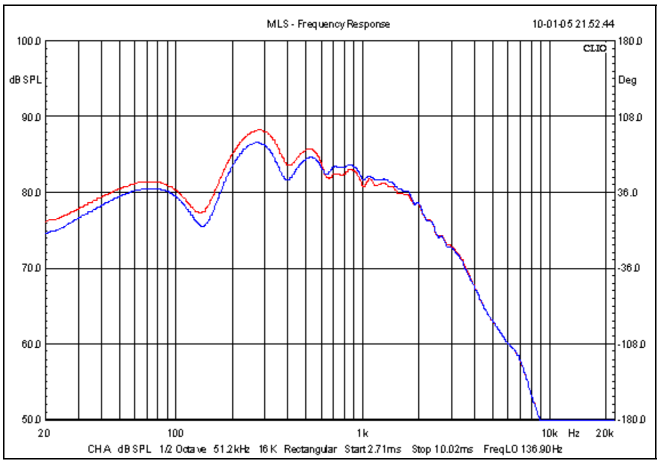

Figure 18.

10 millisecond window. Red = 56 cm baffle, blue = 22 cm baffle.

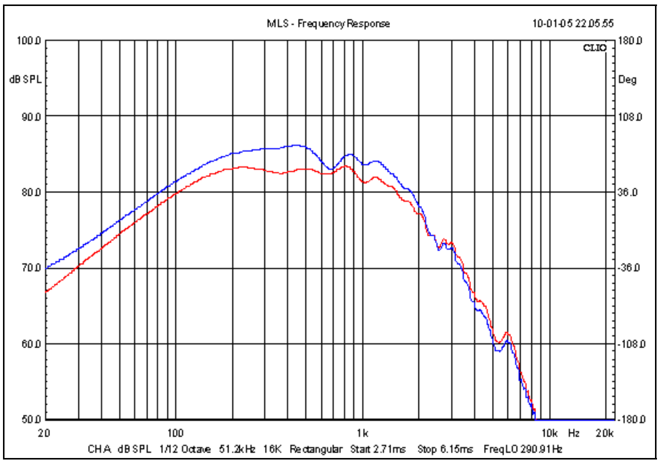

Figure 19.

6.15 millisecond window. Red = 22 cm baffle, blue = 56 cm baffle. (Sorry to swap colours!)
The window here from 2.71 ms to 6.15 ms is without reflections and this narrow window only makes valid readings down to 290 Hz. What's below is not reliable. That's how it goes with MLS measurements.

If we scroll down the measurements we see a successive increase in response from the wide baffle compared to the narrow baffle. From a standard measuring distance of 1 metre and with room-reflections left out we have an overall increase in response of 1½-2 dB - when the crossover is corrected to target a flat response in the midrange - well, even up to lower treble.
You may ask what the response from applying the same crossover to both baffle situations is, and it looks like this:

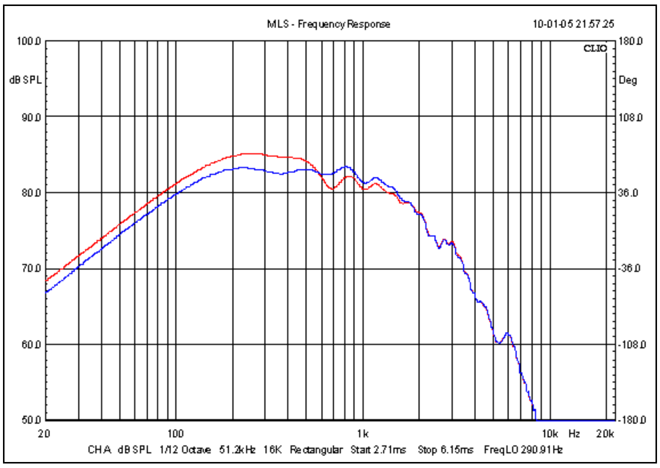

Figure 20.

6.15 millisecond window, same crossover to both panels.

Obviously the increase in response is here limited to the area affected by applying the wide baffle, i.e. below the F3 of the 22 cm baffle: 527 Hz. Well in accordance with theory I should say.

Intermezzo:

Mr. Grumpy:*"What's the use of having an increased response in a limited band when the bass doesn't follow. The bass response is what defines the overall sensitivity of a system and I have a 4 x 200 watts digital amp that will drive my neighbours nuts without any wide curved baffles. Forget it and get a life!"*

Mr. Dee I. Why: *"But I've read all these wonderful reviews of the Stradivari and I want to know what it's all about and why Mr. Franco Serblin has turned his speakers 90 degrees and placed all the drivers on the side of his cabinets."*

Mr. Grumpy: *"What?! Mr. Franco probably thought that all that nice woodwork wasn't seen much from the front and turning them around might catch new customers. And didn't Mr. Ken Kessler write that a friend's wife said these Stradivari were even sexy? Gee, a woman thinking a speaker is sexy! Hmm... maybe I should take a look into this."*

Mr. Dee I. Why: *"Well, there you go.. But I wasn't thinking of sex, rather what the wide baffle does to the way the drivers project the sound into the room, how the speakers react to the room. And maybe I will use a 200 watts digital amp for the bass drivers - and with the increased gain I can ease the life of my tube amp only taking care of the midrange and treble."*

Mr. Grumpy: *"Hmm... No hot bottles for me, but good luck!"*

--o-0-o--

Wide baffle cabinet

Mid-driver and tweeter measurements

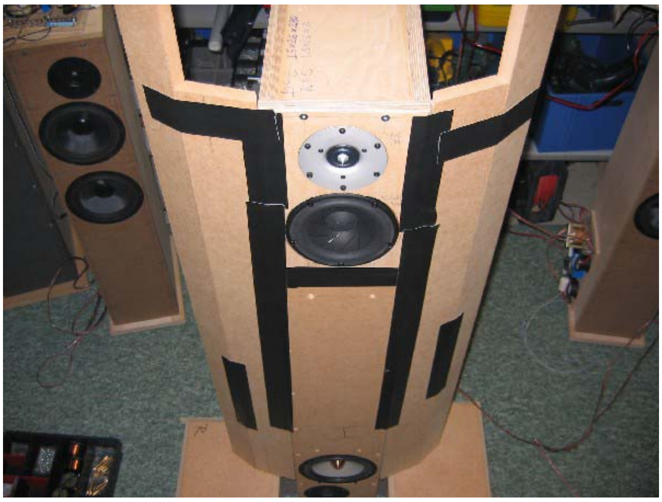

Figure 21.

Above the initial test set-up for the mid and treble. Here the Scan-Speak 15M/4531K00 and the Scan-Speak D2904/7000 tweeter.

Measurements at 1 meter distance:

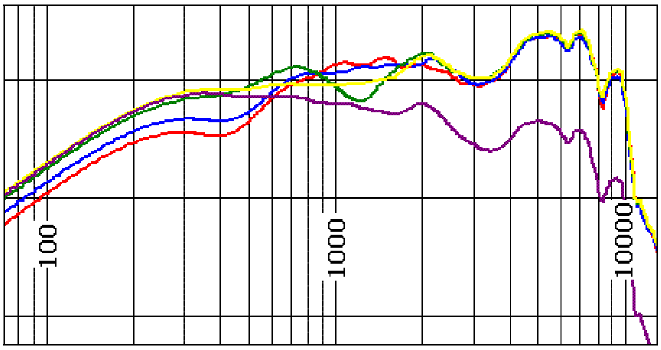

Figure 22.

Measurements are not reliable below 300 Hz due to chosen window.
Red = test cab baffle, 19 x 30 cm (WxH)
Blue = test cab added lower front panel (simply adding a longer front panel adds 1-2 dB from 4-500 Hz downwards.
Green = first pair of side panels added.
Yellow = second pair of front panel added.
Purple = all side panels added and 0.33 mH in series with 4531 driver.

Something interesting happens here: by adding the final pair of side panels a beautiful flat response is seen from 300 Hz to 1.5 kHz. Adding a 0.33 mH coil in series produces a nice response up to 2 kHz.
And most important of all: a 4 dB increase in gain is achieved from the wide panels around 400-500 Hz.

A crossover was constructed for this panel to achieve a reasonable flat response for trying to evaluate the sound from this single speaker.

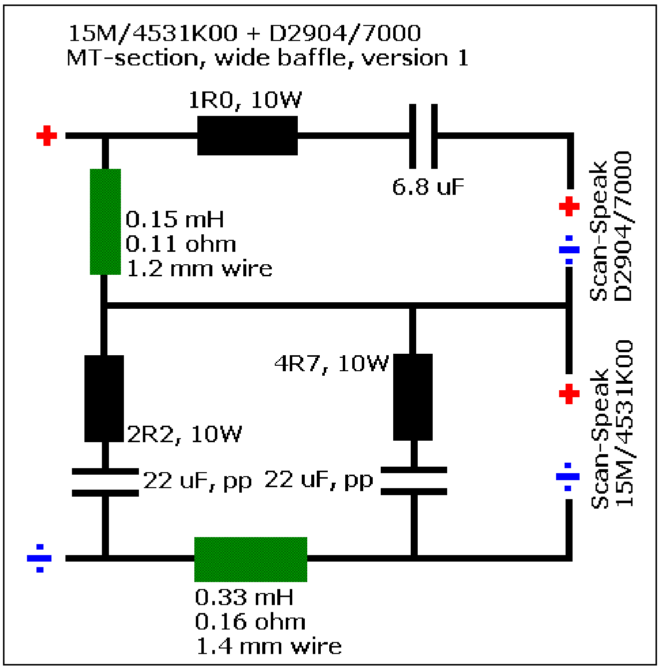

Figure 23

I was a bit surprised the 7000 tweeter didn't require further attenuation, but this is how it looks to produce the response seen below.
I had great difficulty removing the dip at 3 kHz – so, another evening of fine-tuning ahead!

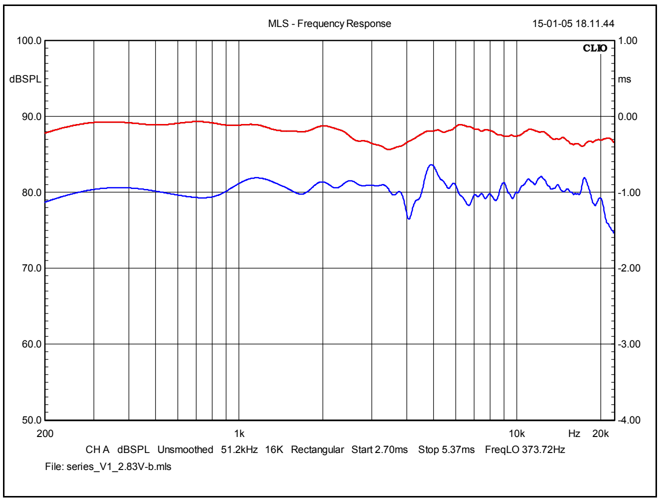

Figure 24.

Above is seen the response at 2.83V/1meter from the Rogers LS35A (blue) and the 4531/7000 (red).
Quite some difference, 8-9 dB. But that does not say we now have a "small" two-way speaker with 3 times the efficiency; the 4531/7000 is a 4 ohm set-up where the LS3/5A is a 10-12 ohm speaker. We are talking sensitivity here, not efficiency.

Sound?
Well, evaluating the sound from a single speaker set-up is difficult but it did sound quite different from what I am used to from narrow front panel speakers and it's premature to say that this set-up sounds like a dipole from a non-dipole.
We need two channels and we need the bass to follow. Some of you may have experienced that adding low-

end bass may enhance the perception of the midrange and even the treble – strange, but true. If you listen to music – at normal listening level – from only what is above 3 kHz, it sometimes sounds terrible and you wonder if there's something wrong with the tweeter or the crossover. But adding the midrange helps a lot and getting the bass in also everything starts falling into place. It appears that we are so used to listening to the world in its full spectrum that limiting this window makes us uncomfortable.
More to follow…

July 2005.

Test cabinets.

Figure 25. Test cabs drying from a quick paint.

Figure 26. First time set-up in the workshop.

So, it's been quite a while since the initial plans were made for this project and it's time to start making test cabs for the wide baffle project. It's always a good idea to make a test cab in order to try if this most important part of a loudspeaker is going to perform as intended. Not least the placement of the drivers will have a major impact on the overall sound and simply saying we're going to use this and that driver, cabinet so and so, crossover this or that order, etc. is much too simple and likely to fail. Ideally we should make a whole range of cabinets with different size and curvature in order to try out what works the best, but obviously this will be too much. Not even loudspeaker manufacturers will do this to a large extent. If they did they might come up with a wonderful sounding but terribly looking speaker that wouldn't sell. Unfortunately for acoustics we very much choose our products by their looks.
Anyway, I took a more practical approach to these very first wide baffled test cabs. The braces and outer panels have these dimensions:

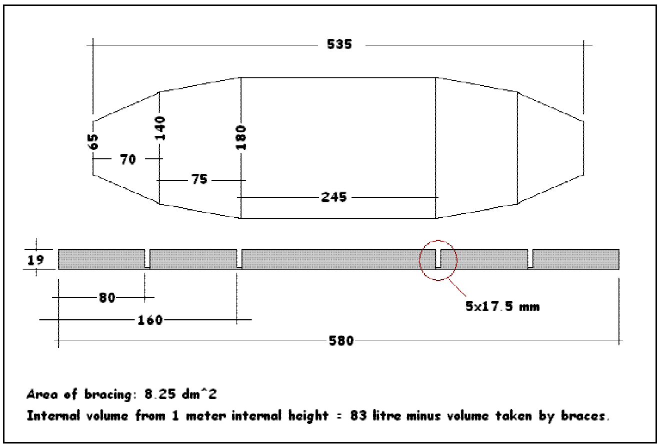

Figure 27.

The cabinet is 120 cm high and has a net volume of 93 litres minus midrange cabinet. The mid section of the front panel will be attached with screws in order to take various drivers as a number of 10" drivers and 2 x 8" drivers are going to be tested.
The slits in the 19 mm panels are 5 mm wide and 17.5 mm deep in order to allow the panel to bend 10 deg. without breaking.

Figure 28.

Figure 29. Bracing used for test simple test cabinets.

Figure 30. First time set-up in livingroom.

Figure 31.

Figure 32. Wide baffle against the Acapella SE.

Sonic evaluation:

Getting the Acapella WB test cabinets into the living room from the workshop (at the basement) was quite a problem and a sack barrow was needed! These cabs are heavy! And before I go on with this story I also have to tell that the current cabinet size and colour has a close to zero WAF. So, you are warned.
Patricia Barber from her Paris live recording was first on the CD player and I think it's the first time I've heard the French introduction with the acoustic scale the male voice requires and the first time I got a real sense of the size of the room where the concert takes place. These speakers have a phenomenal ability to reveal room ambience.
Should you worry about wide baffles having reduced transparency and pinpoint imaging, then you can happily forget about it.
You can never really know how a person perceives the acoustic properties of a loudspeaker no matter how many explanations, but I do think I maybe have an idea of what Ken Kessler means when he writes that wide baffles (Stradivari) sound like dipoles without being a dipole. This is exactly what they do. I have been wondering what he meant by this and thought it was some smart phrasing, but it isn't. The wide curved baffle has a benign way of projecting the sound waves into the room and I'm beginning to think that if you have to choose between reflection and diffraction, then reflection is the way to go. From a wide baffle you really don't have a delayed response of signals - at least not in the frequency domain that counts, upper mid and

treble. And the baffle step really doesn't occur until the sound waves have a length where they are omni-directional anyway.

As always, excitement is high the first time you connect a new pair of speakers. Will they deliver from all the working hours put into them - and these are just test cabs! If they are good I'll have to do it all over.....
Initially I started out with some OEM 10" paper cone drivers. The drivers' basic TS data are: Fs = 23 Hz, Vas = 280 litre, Re = 5.44, Qt = 0.37, membrane mass = 25 grams. Some very light-weight cones - and sensitivity is calculated to 90.8 dB/2.8V.
A vent was added to the cabinet 72 (ID) x 100 mm giving a vent tuning of 28 Hz. Quite low. Nearfield response suggests a quite linear response down to 50 Hz - not bad at all when you add the port response. These speakers should do well below 40 Hz.
The very simple series crossover shown in the pdf file was constructed for the MT and a ruler flat response was measured from 300 to 22000 Hz - the upper limit of the CLIO system.
After having found the subjectively best point of crossover between the bass and mid from using a 24 dB electronic crossover, I constructed a similar passive set-up. Not that easy as the mid is a 4 ohm driver and I don't want the impedance to drop below that. Eventually things worked out and a 3rd order (electrical) crossover was in place and all drivers could be connected with positive polarity.
My expectations to sensitivity were very high (Tannoys still fresh in memory) and I was initially a little disappointed from this until I realised how high I was playing. This speaker can play loud without apparent distortion and it takes an act of will to turn the volume knob down to normal listening level because the level of transparency is so good that you have to hear all the details on every piece of music.
Here's a true contender to the Acapella SE and with a 4-5 dB higher sensitivity. This speaker does not have the absolute neutrality of the Acapella SE and the ability to portray any piece of music with the same grace and fidelity, but it has some more speed and sparkle that may suit some musical genres. Un-treated paper cones are rarely neutral and the SS 15M mid-driver and 10" paper cone bass are no exception from this rule, but the agility and transient attach is something that coated magnesium cones comes short of and something that the home constructor has to be very much aware of before deciding on drivers for a new project.
These speakers handle female vocals very well. They may not be completely neutral, but they can be played loud = lack of distortion. And going from solid state amplification (electronic crossover + 2 solid state amps) to the Copland CTA 505 just brought things into place. Sometimes paper cones and valves go hand in hand and this appear to be the case for the Acapella WB. I'm very hesitant to coat the mid driver. I know it will take some edginess, but also some vividness and well, colouration if you like. It's remarkable that paper cones have survived until this very day despite numerous alternatives with much better physical properties. But well produced paper cones have a "thing" that any other cone material hasn't.
In my small workshop the bass initially seemed a little low in level and extension, but it is not often you can hear anything from a 31 Hz warble tone, but this one can tell you it's there. And getting the speakers into the much larger living room certainly opened the bass and there was the level and extension. The transient attach of the bass could be better (kick drum) and I have to experiment with a smaller cabinet size and possibly a higher vent tuning before I look for other drivers.
Two other 10" bass drivers were tested, a 4 ohms Scan-Speak driver with paper-carbon cone + double magnet and a Scan-Speak 25W/8567-SE alu cone driver. The 4 ohms driver could almost provide the same sensitivity as the 8 ohms paper cone drivers but with low impedance in the bass region and the alu drivers provided some 3 dB reduced sensitivity. For the time being I'm staying with the paper cone although the alu cone appeared to work very well.

First time living room set-up:

Getting the Acapella WB test cabinets into the living room from the workshop (at the basement) was quite a problem and a sack barrow was needed! These cabs are heavy! And before I go on with this story I also have to tell that the current cabinet size and colour has a close to zero WAF. So, you are warned.

Patricia Barber from her Paris live recording was first on the CD player and I think it's the first time I've heard the French introduction with the acoustic scale the male voice requires and the first time I got a real sense of the size of the room where the concert takes place. These speakers have a phenomenal ability to reveal room ambience.

Should you worry about wide baffles having reduced transparency and pinpoint imaging, then you can happily forget about it.

You can never really know how a person perceives the acoustic properties of a loudspeaker no matter how many explanations, but I do think I maybe have an idea of what Ken Kessler means when he writes that wide baffles (Stradivari) sound like dipoles without being a dipole. This is exactly what they do. I have been wondering what he meant by this and thought it was some smart phrasing, but it isn't. The wide curved baffle has a benign way of projecting the sound waves into the room and I'm beginning to think that if you have to choose between reflection and diffraction, then reflection is the way to go. From a wide baffle you really don't have a delayed response of signals - at least not in the frequency domain that counts, upper mid and treble. And the baffle step really doesn't occur until the sound waves have a length where they are omni-directional anyway.

As always, excitement is high the first time you connect a new pair of speakers. Will they deliver from all the working hours put into them - and these are just test cabs! If they are good I'll have to do it all over.....

Initially I started out with some OEM 10" paper cone drivers. The drivers' basic TS data are: Fs = 23 Hz, Vas = 280 litre, Re = 5.44, Qt = 0.37, membrane mass = 25 grams. Some very light-weight cones - and sensitivity is calculated to 90.8 dB/2.8V.

A vent was added to the cabinet 72 (ID) x 100 mm giving a vent tuning of 28 Hz. Quite low. Nearfield response suggests a quite linear response down to 50 Hz - not bad at all when you add the port response. These speakers should do well below 40 Hz.

The very simple series crossover shown in the pdf file was constructed for the MT and a ruler flat response was measured from 300 to 22000 Hz - the upper limit of the CLIO system.

After having found the subjectively best point of crossover between the bass and mid from using a 24 dB electronic crossover, I constructed a similar passive set-up. Not that easy as the mid is a 4 ohm driver and I don't want the impedance to drop below that. Eventually things worked out and a 3rd order (electrical) crossover was in place and all drivers could be connected with positive polarity.

My expectations to sensitivity were very high (Tannoys still fresh in memory) and I was initially a little disappointed from this until I realised how high I was playing. This speaker can play loud without apparent distortion and it takes an act of will to turn the volume knob down to normal listening level because the level of transparency is so good that you have to hear all the details on every piece of music.

Here's a true contender to the Acapella SE and with a 4-5 dB higher sensitivity. This speaker does not have the absolute neutrality of the Acapella SE and the ability to portray any piece of music with the same grace and fidelity, but it has some more speed and sparkle that may suit some musical genres. Un-treated paper cones are rarely neutral and the SS 15M mid-driver and 10" paper cone bass are no exception from this rule, but the agility and transient attach is something that coated magnesium cones comes short of and something that the home constructor has to be very much aware of before deciding on drivers for a new project.

These speakers handle female vocals very well. They may not be completely neutral, but they can be played loud = lack of distortion. And going from solid state amplification (electronic crossover + 2 solid state amps) to the Copland CTA 505 just brought things into place. Sometimes paper cones and valves go hand in hand and this appear to be the case for the Acapella WB. I'm very hesitant to coat the middriver. I know it will take some edginess, but also some vividness and well, colouration if you like. It's remarkable that paper cones have survived until this very day despite numerous alternatives with much better physical properties. But well produced paper cones have a "thing" that any other cone material hasn't.

In my small workshop the bass initially seemed a little low in level and extension, but it is not often you can hear anything from a 31 Hz warble tone, but this one can tell you it's there. And getting the speakers into the much larger living room certainly opened the bass and there was the level and extension. The transient attach of the bass could be better (kick drum) and I have to experiment with a smaller cabinet size and possibly a higher vent tuning before I look for other drivers.

Two other 10" bass drivers were tested, a 4 ohms ScanSpeak driver with paper-carbon cone + double magnet and a ScanSpeak 25W/8567-SE alu cone driver. The 4 ohms driver could almost provide the same sensitivity as the 8 ohms paper cone drivers but with low impedance in the bass region and the alu drivers provided some 3 dB reduced sensitivity. For the time being I'm staying with the paper cone although the alu cone appeared to work very well.

First time living room set-up. Fresh coffee and a stack of CDs and LPs.

15-08-2005 Update Acapella WB

Seen above is a range of drivers suggesting quite some confusion. The 15M4531 ScanSpeak mid driver is gone; the 7000 tweeter is gone and in comes an AudioTechnology driver and a crummy looking old SEAS paper cone driver from the early Eighties. And a 12" JBL bass driver!

There's always a honeymoon with speakers. You may instantly recognise strengths and weaknesses from a new set-up, but it can take days, sometimes weeks to find out whether you can live with the sound from a driver and the way this particular driver will colour the sound, because all drivers do.

The 10" paper cone bass drivers did great and the 7000 tweeter so and so, but the 15M4531K00 driver will drive you nuts in the long run. Scan-Speak has done a fine job in elimination major break-up patterns usually associated wit paper cones but this does not mean this driver doesn't have some residual "paper" (honky) quality to its sound. This driver is phenomenal in accentuating sh... sounds and every sibilant recording will shred you ears. After some time the 15M driver was coated with a coating material obtained from Speakerbits in Australia: http://www.speakerbits.com/Default.aspx. Actually the glue used for refoaming drivers. This material is very well suited for coating paper cones and leaves a nice, non-sticky, flexible surface if done properly. This treatment did not change the frequency response and it improved the sound considerably. For some days I thought this was the cure, but something just kept these drivers having an aggressive sound on certain recordings.

Tweeter attenuation was tested thoroughly and a new parallel crossover for the MT was constructed but this didn't perform better than the former series crossover. Out of frustration I inserted some old SEAS paper cone drivers (actually from a B&O speaker, S25) and well, these drivers do not have the level of transparency compared to the 15Ms, but vocals just started sounding right, actually very good. Hmm... Seriously, a 25 old el-cheapo driver! Next I took a Monacor SPH 175 driver, actually quite similar to the SEAS driver. This driver has a coated paper cone and I removed the terrible plastic dust cap and inserted a phase plug from an old SEAS driver. Again, some very enjoyable midrange and good vocal performance.

Replacing the 15M with these new drivers took some extensive crossover modifications every time. There's no plug and play in this business....

I've had good times with the Scan-Speak 15W/8530-K00 and -K01, but this 15M/4531K00..... Sorry, not my cup of tea.

So it was time to reconsider the whole project.

A pair of JBL 123A drivers in mint condition caught my attention at eBay and I've always wanted a pair of these and so I had - for a reasonable amount of money. Not often you get two exquisitely build, mint condition 12" bass drivers for 150 US$. I knew these bass drivers would have a relatively high Qt and probably would perform best in 80-100 litres closed cabs and they might be worth a try in the Acapella WB. My measurements on the 123A: Vas = 225 litres, Fs = 25 Hz, Re = 4.4, Qt = 0.49.

JBL 123A Signature. This driver has a remarkable frequency response. From the wide baffle cabinet they perform +/- 1.5 dB
from 200-6000 Hz! No serious break-up at all. No wonder this driver can run full-range in the JBL L100 Century monitor helped
at the top by the LE5-2 midrange and LE25 tweeter. And the 123A drivers are sensitive, 90-91 dB/2.8V.
A good starting point for the Acapella WB.

Next test set-up.
The midrange driver:
Midrange - the ever so troublesome midrange! I always thought that the Acapella should not be a "true" clone of the Stradivari with regard to driver selection - it would be too easy to take 2 x SEAS W26EX001, a 4" AudioTechnology mid and the 7000 tweeter to get as close as possible to the Stradivari. But the target is to maintain 8 ohms impedance and so it will be.

But having some 4H52-06-13 SD AudioTechnology drivers, these were an obvious choice for a new set-up. The 4H52 drivers are very broad-banded and can easily perform up to 3500 Hz and the Fountek JP3 ribbon tweeter is feeling good from this point of crossover (p.o.c.). Thus a new set-up was in place as depicted above.
The 4H52 drivers used are not standard drivers; they have an underhung voice coil, only 6 mm wide in a 13 mm magnet gap. The membranes are made from 500 my polypropylene and they have a concave centre "dome". And they obviously have symmetric drive (SD).

The 123A bass driver was tested in a vented and closed version of the cabinet and vented so far sounds the best although the difference is small. Vent tuning is 25 Hz. A three-way, 24dB LR electronic crossover was inserted and with the CLIO measuring system a reasonably flat FR was obtained with points of crossover at 400-450 and 3500 Hz. Finding the right point of crossover between bass and mid driver is the most tricky part and as the electronic crossover has continuously adjustable points of crossover, it's a good experience to slowly change the point of crossover from 100 Hz to 800 Hz while listening to vocals. Taking the p.o.c. down to 200 Hz, this set-up starts sounding like a pair of satellites with added sub-woofer. Not good! Moving up to 600-700 Hz has a negative impact on vocal performance as well, although it's difficult to describe how. Vocals just don't sound right from the 12" driver. Looking at some large classical British speakers like the IMF, Radford, etc., we will often find a p.o.c. around 300-475 Hz from using a 10-12" bass driver and a 5" midrange. (The 4H52 really is a 5" driver, but Skaaning is just being honest about membrane size).
Listening to a wide range of recordings this set-up proved worthy of constructing passive crossovers targeting these points of crossover. From the electronic crossover the bas and mid produce a good frequency response, but the individual phase response wasn't too good. Something that may be more easily managed with a passive crossover and produce an even better bass-mid integration.
Frequency and impedance files were produced from all the drivers; the 123A measured at ½ meter distance and attenuated 6dB. This usually goes well for modelling. The benefit is a much reliable lower FR for the bass driver for modelling.

February 2006:

After a long break from the wide baffle speakers, I finally put together the crossovers for the JBL 123A + AT 4H52 + Fountek JP3 ribbons, based on the simulations I made half a year ago and initially the points of crossover were 300 and 4500 Hz. 4500 Hz is really high for the mid but I wanted to hear how the 4H52 would perform from this. The 4H52 can manage well up to 5-6000 Hz, but treble produced from a 5" cone isn't my cup of tea. The 4500 Hz p.o.c. went reasonably well despite minor honkyness, but transparency was excellent. Actually so good that I decided to go for this solution. Polypropylene cones may not reveal the absolute ultimate level of transparency but this is so close to "it" that I decided to pay Per and Eivind Skaaning a visit to have them make me two middrivers with some differences to the 4H52 FlexUnit here. The drivers will have 52 mm voice coils of 15 mm length wound on a kapton former in a 6 mm deep magnet gap, standard convecs domes and finally it will have the H magnet. With the given choice of polypropylene thickness, a sensitivity around 91 dB should be the result. The driver will have the C-Quenze chassis and it will be named 15H52-15-06-SDK.

Per Skaaning is a great adviser on how to design the drivers you want and you may come with a lot of ideas of how the driver should be, but from Per's practical experience the outcome of such a discussion may be different from what you had in mind. I very much thought that underhung voice coils would be the way to go here but the transient attack is better from overhung voice coils and the frequency response produced from overhung voice coils is better suited for midrange. Underhung voice coils may produce a more flat frequency response well suited if the driver also has to play bass - despite limitations in Xmax.
So, while waiting for the drivers being made it's time to think about the whole project again. The test cab "as-is" is definitely too large to render a green light for living room placement. 45-50 cm width is OK but height has to be reduced to between 100 and 110 cm. Depth is not a major issue, which is nice as we get a lot of volume from increasing depth even a little. But the JBL bass driver? Good question. The JBL 123A drivers do fine with the current 80 litres volume but a smaller cab added Variovents may do fine too. Having Per Skaaning make 2 x 8" drivers suitable for a total of 60 litres volume would be easy - and costly! And we could order 10 ohms voice coils to produce an impedance that wouldn't kill our valve amps. Very easy too!
A very well-known high-end system having two 8" bass drivers in an approx. 60 litres cabinet get along from using some rather unusual drivers: Fs = 35 Hz, Vas = 41 litres, Re = 5.4 ohms, cone weight = 35 grams and Qt = 0.40-0.45 (depending on voltage applied). This makes an F3 around 40 Hz in a 30 litres vented cabinet and the room does the rest - I hope, because the company claims a 25 Hz extension! Well, well... These bass drivers have a rather rigid suspension. Feels like drivers for subwoofers used in cars actually. But who cares - if it works. I have some 10 ohms Dynaudio 21W54, but will two of these go deep enough? Only experiments can tell. If the new suspensions they're having will reduce Vas a little and increase Qt a bit - it might work.