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From concept to launch –  
The story of the Aequo Audio Stilla loudspeaker

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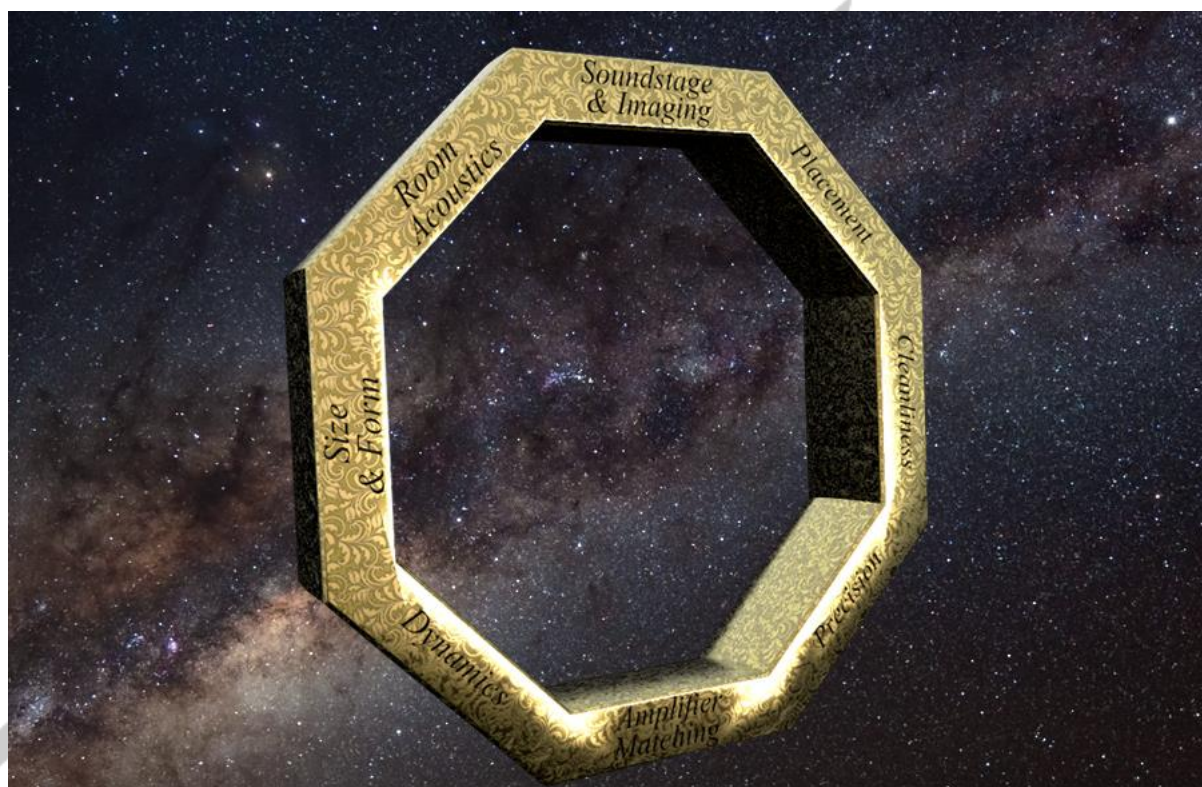
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## Company - Introduction

Aequo Audio was established in 2012 by a team of music and hi-fi enthusiasts. Situated in Brainport, Eindhoven, the Netherlands, one of the leading high tech regions of the world, the focus of this new innovative company is to create and manufacture innovative loudspeaker solutions for the audiophile market.

Determined to get an enhanced 'musical message' to a broader audience through dedicated listening rooms around the world and ultimately into the living rooms of all music lovers, Aequo Audio places emphasis on in house R&D and adopts an Octagon philosophy which has been incorporated into its company logo.



Aequo Audio's first model, the Ensis Loudspeaker, launched in May 2016 won many prestigious journalistic awards. The success of this product has allowed the team to expand and enhance our manufacturing facilities and invest in new equipment including state of the art 3D

printing, for rapid prototyping and testing, along with a fast and highly precise CNC German routing station.

To compliment the Ensis Loudspeaker Aequo Audio have now launched a smaller complimentary product: the Stilla.



Awards for the Ensis loudspeaker



*CNC routing station*

The designers and engineers at Aequo Audio believe in the philosophy of their locality: *innovation through collaboration, research and technology*. This is achieved by utilising the advanced measuring facilities of the Technical University of Eindhoven along with having close and established relationships with local suppliers that are compliant to the extreme high standards in quality and precision., typical for Brainport manufacturers, such as the multi-billion corporation ASML, which is the global leader in chip making equipment.



*Aequo Audio's team member Pierre passing products through quality control, using high-precision measuring equipment provided at one of our local supply partners before delivery.*

For the development of very specific loudspeaker parts, such as driver/transducers and filters, Aequo Audio work alongside specialists from Denmark, a country known for producing some of the world's best drivers. This collaboration has been driven by the historical development of transducer innovation led by Ejvind Skaaning.

Skaaning started his career at Seas in Norway, at that time one of the leading pioneers in hi-fi technology. After this, he returned to Denmark and founded Scan-Speak (still using the brand nomination derived from his name) and Dynaudio. Colleagues that worked alongside Skaaning and/or at Scan-Speak have gone on to start brands such as Vifa, Peerless, Wavecor and SB-Acoustics.

Skaaning's legacy and the accumulated knowledge of his co-workers is represented in all the drivers that have been developed in collaboration with Aequo Audio. One of the finest examples of this is the midbass driver used in the

Ensis and Stilla speakers which was born from working with Ejevings' son; Per Skaaning.

The collaborations that have been instigated by Aequo Audio allow the company to continually 'push the boundaries' with regards to the achievement of the best possible musical reproduction. The results of these collaborations are manifested in the recent Diluvium prototype, an ongoing exploration of what is possible regardless of cost, along with the new Stilla loudspeaker at a more affordable price point and positioned just below the Ensis.



*Stilla loudspeaker (left) and the Diluvium prototype (right)*

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# Stilla - Design Choices

Choosing not to produce a watered-down version of the Ensis speaker, our mission was to make the best possible loudspeaker for a MSRP of approximately 18.000 euro. The specification needed to deliver maximum musical enjoyment for a spectrum of customers starting from those who simply enjoy listening to music, up to the highest demanding audiophile.

Using the Aequo Audio Octagon philosophy, the scope of the Ensis development work included, the size and form of the product, the room acoustics, the sound stage and imaging, the placement of the speaker, cleanliness and precision of the musical reproduction, along with amplifier matching and dynamics.

## 1. Size & Form

The in-house developed ARPECT™ system enabled us to deliver full-range dynamics from small cabinets to maximise the lowest frequency output from the transducer. Much of the Ensis special configuration, resembling a musical note, was derived from the desire to fit a full size 10 inch subwoofer into a compact cabinet. This special shape itself was a production challenge, and as the single semi-side firing 10 inch membrane demanded ultimate strength and stiffness of the cabinet. This presented the necessity of in-house development of special materials including our company's proprietary Grey Matter Compound™.

Aequo Audio had a desire to make the design suitable for the widest possible audience, so the size of Stilla had to be minimised to partner well in any domestic environment as well as being non-interfering in dedicated listening rooms. The vibration cancelling positioning of two smaller subwoofers was explored along with the availability of extra dynamic headroom that could be delivered by bass reflex and horn loading in the lowest octave.

## 2. Room Acoustics

At Aequo Audio, we had a clear goal to deliver a speaker that would both work well in virtually every room and could reach the best acoustic performance level for a specific room. The benefit of a small, not box-shaped speaker, resulted in less room interference in any room however, the reflecting or absorbing sound qualities had to be taken into consideration. To do this, the EHDL™ high frequency transducer system used in the Ensis and Diluvium, was implemented in the Stilla, making it a good partner for a huge variety of furnished rooms. The addition of a newly developed version of the ARPECT™ low frequency control system made adjustments to various rooms possible and solve bass problems sometimes encountered trying to match a given speaker to a specific room. Meanwhile, the incorporation of an easy tilt adjustment in the speaker's foot ensured that the speaker could be perfectly matched to the height and distance of the listening position in the room.

## 3. Sound stage and imaging

Some of the discoveries made whilst developing the Diluvium prototype showed even further possible improvements in the huge three-dimensional soundstage that the Ensis is known for, and these were incorporated into the Stilla. This includes further elimination of unwanted indirect sound reflecting of the front and top panel of the speaker by the application of a special absorption material. Furthermore, the EHDL™ system, its acoustic lens and dispersion cone, were tailored specifically to the speaker's dimensions and features, whilst a filter topology with low order crossover slopes between drivers and low tolerance in variance of component values, were also employed to throw a marvellous soundstage with realistic and accurate imaging.

## 4. Placement

Aequo Audio does not produce floor standing speakers with rear ported cabinets as we believe that this limits the speaker's placement options. Speakers with rear ports will only be well balanced in their bass performance when placed at a specific position from the front wall. In many instances this reduces the maximum achievable soundstage and imaging options, or produces "boomy" excessive bass when the user is limited for space.

To also avoid another problem common for ported speakers: the audible group delay in sound produced by the port's output, Aequo Audio designed the Stilla to be totally 'slow' bass free, by tuning the port to work in the pressure domain, rather than the time domain, as well as by using a further developed ARPEC™ version to control the acoustic properties of the bass roll off. The results in the time domain are close to the ideal signature for fastest bass, now for the first time regardless of cabinet topology.

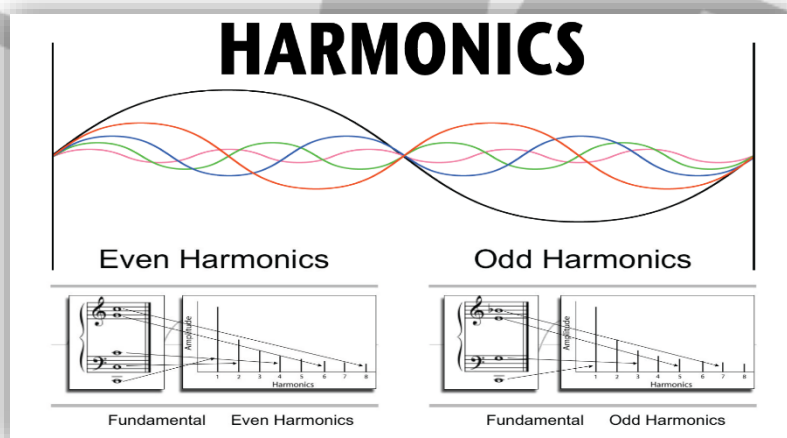
The incorporation of the placement adjustment of ARPEC™, similar to that found in the Ensis, ensured that the Stilla's performance was uncompromised whether located in the corner or far away from the walls of the listening room. The adjustments can be made speaker-individual to effectively counter any difference in sound caused by asymmetry of the two speakers with regards to their closest boundaries.

## 5. Cleanliness

Aequo Audio had already gained extensive knowledge with regards to avoiding unclear, distorted sound that could negatively affect music reproduction. This includes knowledge of how all driver's cones, suspension, basket, and motor design, can cause unwanted side effects at very low, normal and up to very high listening levels. The driver design of the Stilla employs the latest technology by Aequo Audio and its partners, to sound so free of noise and distortion up to (or down to) levels rarely seen in speakers.

But, we are also aware of the important balance between even and uneven harmonics and their ideal sound levels at specific ranges in frequency, and even in specific relativity to various listening levels. The company's products all carry a specific harmonic distortion signature in their musical reproduction that reveals a high level of subjective and emotional understanding of how to make the distinction between unwanted distortion and the welcomed resurrection of lost musical harmonics that were lost during the recording process.

Coupling the above to our R&D efforts in cabinet material science, and utilising state of the art acoustic measurement equipment, the Stilla was designed to produce unprecedented musical qualities at its price point.





*Aequo audio uses high precision equipment, as calibrated iSEMcon products for measurements*

## 6. Precision

Many insiders and outsiders of the loudspeaker business still focus on various speaker transducer characteristics to wrongfully explain differences in precision, resolution or “airiness” in the reproduction of detail. One of the usual suspects in these stories is the weight of moving parts whilst another is the material of choice for these parts. However, the weight of moving parts is mostly just important for sensitivity. Heavier means that more energy or watts, are needed to achieve the same acceleration of the movement. With regards to material choice, some materials that are extremely stiff, when used in midrange and high frequency drivers’ cones, can add ringing sounds that work for a spectacular first encounter of the speaker but end up causing an unrealistic and fatiguing experience. Counter-measures to alleviate these ringing distortions are present in many hard cone/dome midrange and high frequency drivers today but, these almost always include high order filters that without exception compromise the time domain and coherency of the speakers involved.

Aequo Audio’s knowledge of using superfast, controlling motor designs on stiffer materials in the bass-section and softer, good self-dampening cone/dome materials in the mid/high section, has been used in every product that we make. The Diluvium prototype has the highest possible measured and interpreted resolution in moving coil transducers known today, without the use of extremely stiff membrane materials. Even though well-behaved, by using well self-dampening cones, this enhanced resolution can be challenging with the listener noticing some recordings that are of a lesser quality. This is especially true for the 1000-6000 Hz region where ears/minds are most perceptible to such shortcomings and where it can distract from bringing the musical message to the listener.

In our product portfolio we offer different steps of resolution in differently priced products. The Diluvium prototype benchmarks ultimate resolution at all frequencies by using a four way design, whilst the three-way Ensis takes a step from there towards overall smoothness, still standing out in detail above virtually any speaker in its segment. Although the Stilla takes another step back to be more forgiving by adding high frequency smoothness, it still offers a natural, airy and fast playback, not any less detailed than other speakers at this price point. Coupled to this, the Stilla has benefited from being equipped with one of the many tested motor prototypes of the Ensis tweeter, namely the one that has the best balance between overall smooth musicality and detailed transparency. Meanwhile, the highly precise midbass driver of the Ensis has been included into the Stilla design unchanged, as the ear/mind will take less notice of the level of fault-analysis of some recordings in this frequency-band, whilst the use of a first order filter between mid and high frequencies ensures a problem-free crossover and overall coherency in wideband transparency.



## 7. Amplifier matching

In our desire to make speakers produced in-series that could enhance the musicality for a large group of potential customers using a range of amplification, Aequo Audio soon discovered there were many amplifiers that would in general either:

- Lack power (outside specified power)
- Lack control (sometimes outside listed dampening factor)
- Sound too analytical or bright
- Sound too warm and fuzzy

To overcome these issues, the amplifiers had to be endlessly tried to work best with other components in the system, especially the speakers. It often results in a compromised choice between musicality and aspects like grip and cleanliness. Even despite ultimately finding the best possible value in the best possible match, it often still asks for a big overall budget for the system as a whole.

We learned that for some of the potentially most musical sounding amplifiers, the frequency bands, where most is asked of the power amp modules and power supplies, could harmfully affect other frequency bands and overall performance in all aspects. By incorporating our hybrid designs, using active powered bass drivers, we could solve many of these issues and make connected amplifiers sound much better than they ever did before. Additionally we made the moving parts of the passive mid/high section extremely light and with incredibly effective motors, so that we can offer speakers with respectively 93db, 90db at 8 ohms nominal (ie. 96 and 93db at 4 ohms nominal, near horn speaker performance) for the Diluvium prototype and Ensis speaker. For the Stilla we wanted to match the Ensis sensitivity and 8 ohm nominal workload to work with virtually any amplifier considering power output, impedance and damping factors, to provide listeners with better performance versus value in their system of choice.

With regards to the tonality, timbre and overall musical character of the amplifier, the combination of highly controlling, fast precision motors, on well self-dampened cone/dome moving membranes, brings out the best in over-forgiving or slower amplifiers, as well as the more analytical equipment. The Stilla does not put any emphasis on clinical sound by resonance of hard materials on such amplifiers, while always delivering musicality, impressive detail and air.

## 8. Dynamics

With regards to dynamics Aequo Audio's focus was not just on being able to play music boldly and loudly but on the total dynamic spectrum including how the speaker reacts on dynamic differences within a recording and ultimately how louder and softer sounds are reproduced together as a whole at the same moment in the recording.

With regards of such dynamics, an important aspect of a speaker's moving parts, is how their movement is controlled by some mechanical parts acting as a spring. If the spring's force on the moving parts rapidly increases with bigger movements, this will hurt the dynamics by adding a lot of compression. Unfortunately, with some of today's commercially successful speaker brands, there is a trend to use less expensive, less gripping, motor designs on a moving midrange cone that has little free movement. This kind of cone control will easier achieve low amounts of distortion without the need of a top class and expensive driver motor. But, as in the midrange still quite some movement is required from the driver's cone, limiting free movement under these requirements will also bring a lot of added compression to the table. These speakers are easily recognisable as they do not use a real rubber or foam surround around the cone to allow free movement, and they are often sounding mechanical, suppressed, non-emotional, and most suited for already maximum compressed and compromised pop music in hope of its shortcomings could go unnoticed.

Aequo Audio designed the Stilla with powerful controlling, detail-revealing motors, using widely linear suspensions and surrounds made of low-loss rubber, which does not degrade over time like foam, on both the low and mid-frequency drivers. The result is a natural open sound, not adding further unnecessary compression into the musical reproduction. Meanwhile, with regards to the loudness of the speaker whilst remaining linear and uncompromised, the Stilla speaker was designed to be the most dynamically powerful speaker in full range for its size.

## Stilla - Specifications and Features Overview

Aequo Audio has successfully designed the Stilla: a new speaker that meets all the demands discussed in the previous chapter, based on the design choices made accordingly. In the table below you find the most important specifications in a comparison with the Ensis. On the next page you find a picture showing the most important features.

	Stilla	Ensis
Size (h x w x d)	107 x 16 x 26 cm	116 x 31 x 29 cm
Weight	20 kg	25 kg
Sensitivity db SPL 2.83V	90	90
Numer of drivers / driver topology	4 / 3-way	3 / 3-way
LF enclosure type	horn loaded bass reflex	closed
Enclosure Materials	s-stone, wood, billet aluminium	wood, s-stone, Gray Matter Compound™, billet aluminium
Frequency range hz	14-35.000 hz (depending on room and settings)	10-40.000 hz (depending on room and settings)
Average in-room -3db extension on roomsize XXL	18hz	16hz
Impedance	8 ohm nominal	8 ohm nominal
High frequency transducer	doped s-silk dome-ring, high speed ferrite motor	doped s-silk dome-ring super high speed ferrite motor
Mid frequency transducer	mineral filled PP, super high speed ferrite motor	mineral filled PP, super high speed motor
Low frequency transducer	double 7 inch Nomex coated, symmetric motor large excursion	10 inch aluminium, symmetric motor large excursion
Connection terminals	WBT	WBT
Electronic Adjustments	2: Roomsize XXS-XXL, Placement	2: Roomsize XXS-XXL, Placement
Manual Adjustments	cabinet tilt by single wheel	adjustable feet
Aequo Audio Technology	EHDL™ ARPEC™	EHDL™ ARPEC™ Grey Matter Compound™
Amplification hybrid version	Ncore 2 x 250 watt	Ncore 500 watt
Additional amplification full active version	Ncore 100 watt	Ncore 2 x 100 watt

ARPEC™ analogue control hardware with room size and placement adjustment rotators

First order passive, wideband phase aligned crossover filter

2 X 250 watt Ncore amplifier with optional 100 watt full active system

Vibration separation between mid/high and low frequency cabinets

Pressure ellipse-formed artificial stone

Finnish plywood matrix frame

Epoxy lining derived from Gray matter compound

WBT terminals with Powercon mains connector

Steplessly adjustable tilt control

Rounded top and sides for minimum diffraction

EDHL™ high frequency system

Superfast, superclean high self-dampening midbass transducer

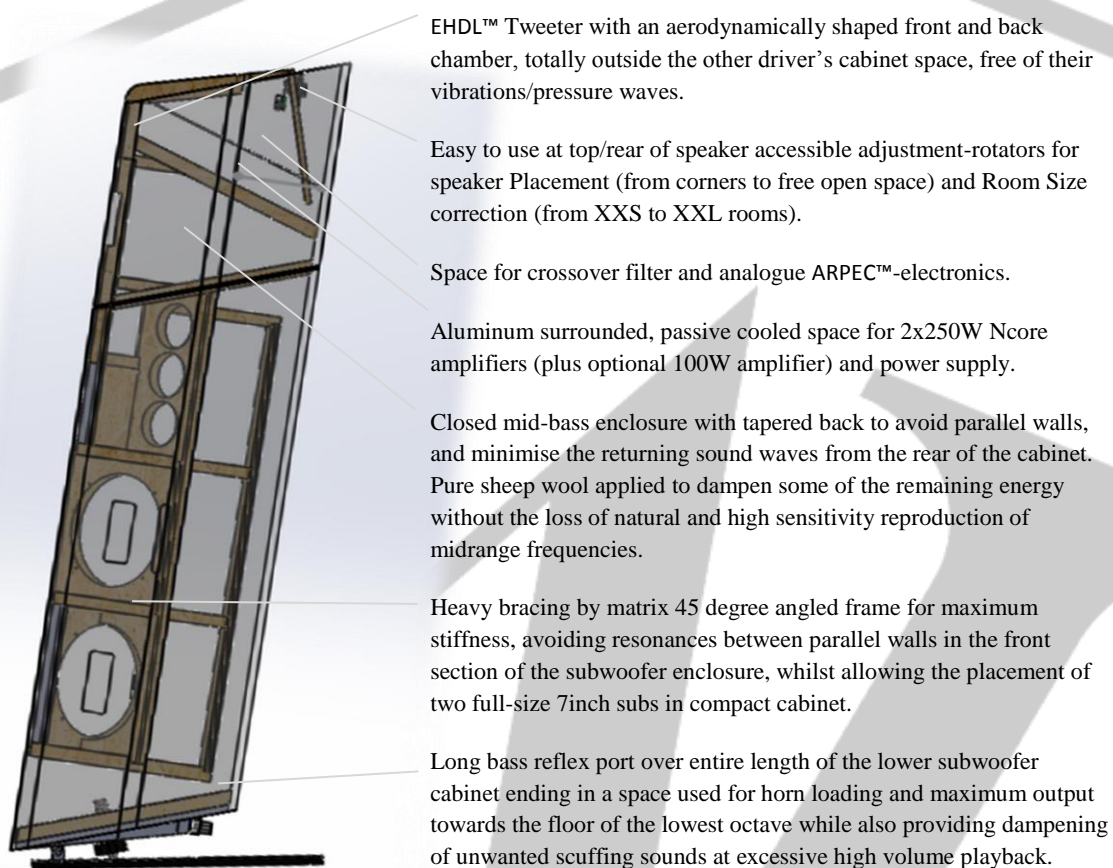
Wool felt front and top cover minimising indirect sound

Double 7" active powered high linear excursion subwoofers opposed at 45 degrees

Front horn loaded bass reflex port tuned at 20 hz controlled by ARPEC™

Sandwiched aluminium/artificial stone vibration absorbing feet

## Stilla - Cabinet Construction



EHDL™ Tweeter with an aerodynamically shaped front and back chamber, totally outside the other driver's cabinet space, free of their vibrations/pressure waves.

Easy to use at top/rear of speaker accessible adjustment-rotators for speaker Placement (from corners to free open space) and Room Size correction (from XXS to XXL rooms).

Space for crossover filter and analogue ARPEC™-electronics.

Aluminum surrounded, passive cooled space for 2x250W Ncore amplifiers (plus optional 100W amplifier) and power supply.

Closed mid-bass enclosure with tapered back to avoid parallel walls, and minimise the returning sound waves from the rear of the cabinet. Pure sheep wool applied to dampen some of the remaining energy without the loss of natural and high sensitivity reproduction of midrange frequencies.

Heavy bracing by matrix 45 degree angled frame for maximum stiffness, avoiding resonances between parallel walls in the front section of the subwoofer enclosure, whilst allowing the placement of two full-size 7inch subs in compact cabinet.

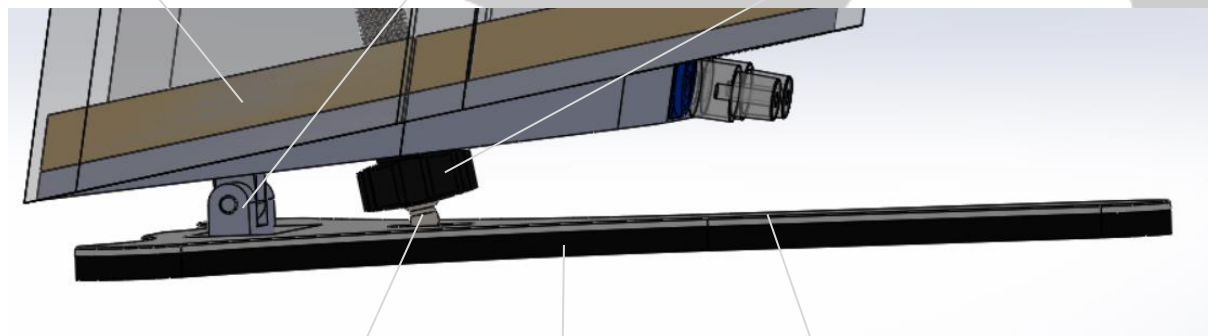
Long bass reflex port over entire length of the lower subwoofer cabinet ending in a space used for horn loading and maximum output towards the floor of the lowest octave while also providing dampening of unwanted scuffing sounds at excessive high volume playback.

## Aequo introduces various new leading edge features into the unique design of the Stilla, including the innovative adjustable foot.

Heavy, Almost two inch base thickness

Pivot with four vibration dampening bearings

Easy to use, single star-knob for stepless tilt adjustment



Free moving stainless steel ball-end that transports the full weight of the speaker, filtering out sideways movements.

Pivot and ball end contact stiff aluminium base changing remaining single direction vibration remaining energy into heat.

All unwanted resonance of the aluminium is effectively dampened by a layer of artificial stone.

Aequo Audio designed the outer shell of the cabinet from the lessons learnt from Ensis production methods and material choices. The 16cm wide ellipse shape in the Stilla was carefully optimised against unwanted resonances along with being preferable over constant/single radius shaped concave walls for being less susceptible to internal material resonances as well as not diverging internal pressure/sound waves to a single point (the centre point of the wall defining circle).

For the Ensis, we had developed the milling and seamlessly gluing of artificial stone. To obtain the best possible material we worked alongside a nearby supplier and had used a double thermo infused process to get the ceramic particles in-situ with the acrylic bonding material. This resulted in an artificial stone material superior to that of well-known versions like Corian, which showed the improved tolerances that were needed to successfully manufacture the material in combination with wood along with a similar weight, strength and stiffness to that of real granite.

*Aequo Audio Artificial Stone specifications:*

<i>Property</i>	<i>Standard of measurement</i>	<i>Value</i>
Thermal expansion per degree of temp.	DIN 53752	<0,005%
Tensile strength	DIN/ISO 527	45 MPa
Stiffness by modulus of elasticity	DIN EN 310	8000 N/mm <sup>2</sup>

At the time of developing the Ensis, we were already aware that the high quality material had excellent thermoforming properties, although it was still limited for small radiuses such as the “point” of the ellipse shape. For the Ensis, we use a custom in-house built 20 ton hydraulic press, for the multi-layered, multi-type wood shell, glued together and formed under high pressure. Now combined with our new industrial high-precision oven equipment, this same press can be used while thermoforming thick plates of artificial stone into the perfect Ellipse shaped outer walls of the Stilla speaker. The development of this process was extensive and included the production of numerous molds, the usage of various tools and detailed measurements and evaluations at every stage before the design was ready to be fully optimized for ongoing production. The end result was an almost zero fall-out production rate and a speaker product that sets new standards in high-end acoustic properties of compact high internal volume speaker cabinets.



*For development and production of the new Stilla loudspeaker, Aequo Audio had a jump start by using numerous lessons, materials and tools earlier explored for the Ensis Loudspeaker, and went forward by implementing them in new ways.*

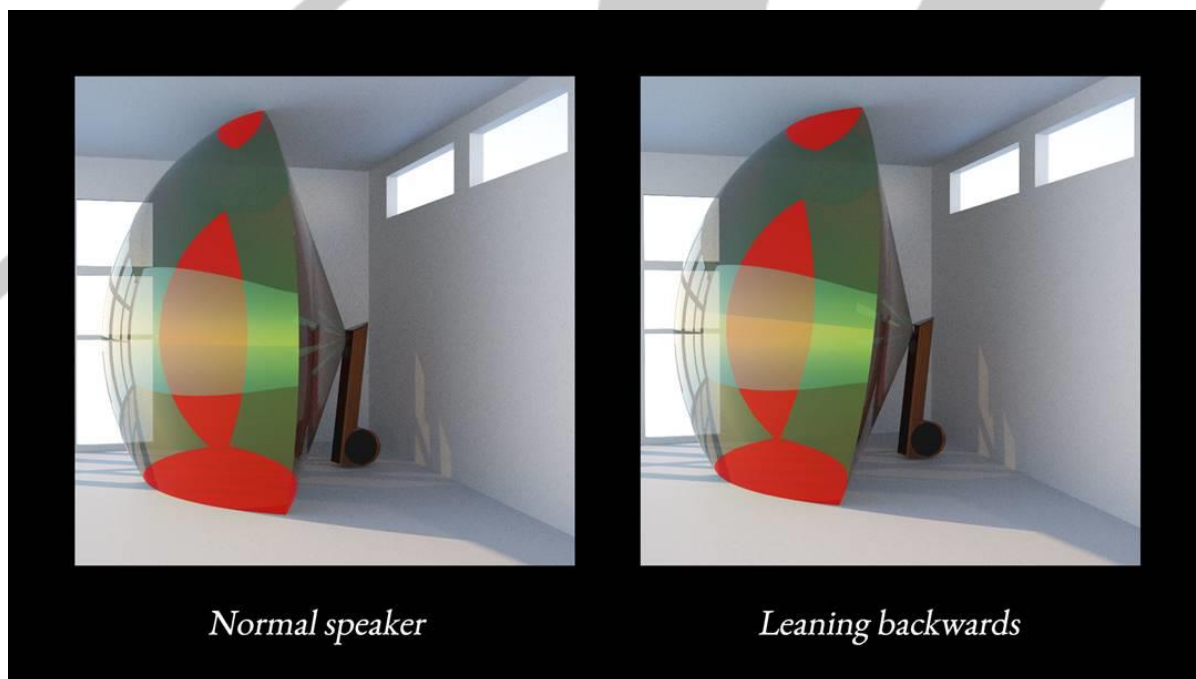
## Stilla - Musical and Measured Performance

Aequo Audio ensured that the measured performance of the new Stilla Loudspeaker, especially in terms of cleanliness and high resolution precision, was very close to that of the Ensis speaker, with the same musical balance between even and uneven harmonics at all listening levels. From 100hz-20khz uneven harmonics are close to 0,1% or even significantly lower in the most important frequency domain where ears are most sensitive and easily fatigued by “false detail”. Measurements showing the exceptional distortion performance were earlier published by Aequo Audio after the launch of the Ensis speaker.

Whilst the Ensis is still superior in low frequency distortion by having a large 10 inch subwoofer on board, Aequo Audio chose for the Stilla a slightly more forgiving motor design in the tweeter. It differentiated the two especially in high frequency resolution, to have the Stilla provide the still very open, but slightly smoother musicality desired by a wider audience. The tweeter system all together, is a specifically tailored version of Aequo’s EHDL™ system.

Instead of focusing on an as flat as possible frequency response on-axis or for a specific angle to the speaker, Aequo Audio looks at the energy distribution/dispersion in all directions at any angle. Aequo Audio studied how this energy is reflected, or how it is absorbed. The speaker’s energy dispersion pattern must work together with the room to make sure the right amount of energy reaches the listener, even when that can be at different positions. It also has to work with the room to make sure everything goes well in the time domain: later arriving reflected sound can be filtered out by our brains, but not if it arrives too close behind the original sound.

The commonly seen, fully round acoustic lens or waveguide (left picture below), will help the speaker to have less problems with a small “sweet spot” and lack of general absorption by the room, and it will also widen the usable bandwidth of the tweeter. Often required to work at best, the speaker with waveguide should still be tilted back, to fire a bit more energy towards the further away ceiling compared to the floor.

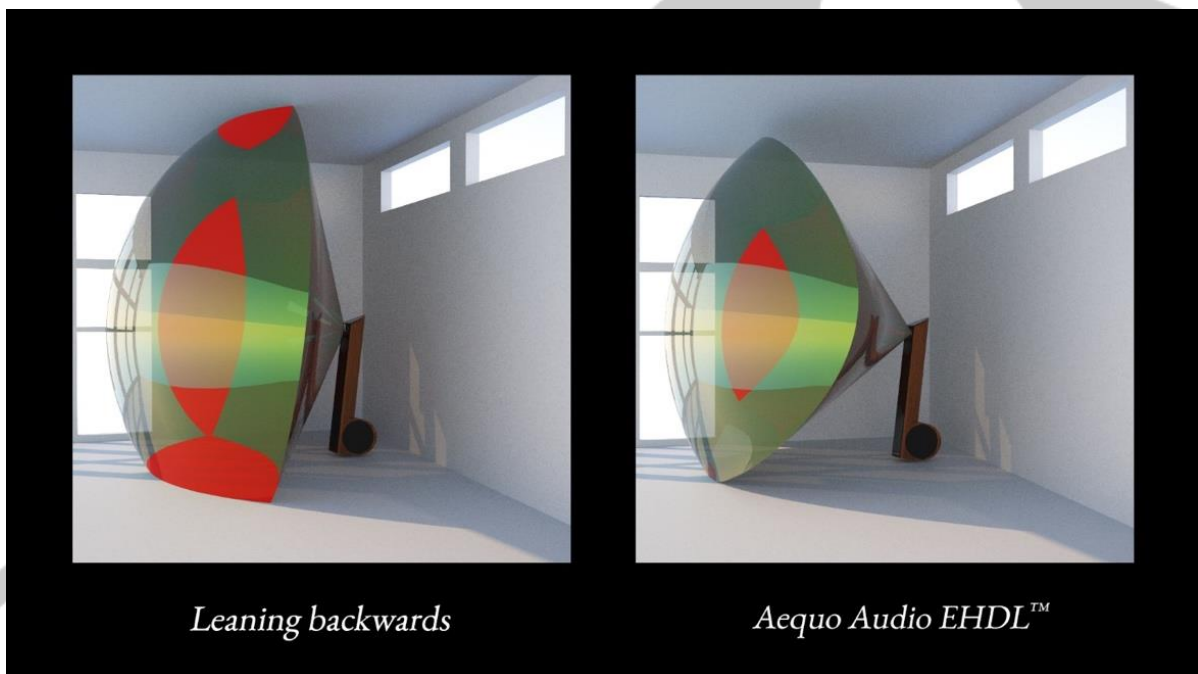


*Two Ensis speakers fitted with an ordinary round waveguide showing distribution of sound energy by the tweeter. Red areas are sound reflecting from side-wall, floor and ceiling.*

The tweeters commonly used in these applications (dome, ring or cone) excels over vertical shaped ribbons/AMT in cleanliness versus size, but, in some more difficult rooms with hard floors, they can be surpassed by ribbon/AMT in one aspect especially: the holographic soundstage and imaging. This is due to the limited vertical dispersion of the ribbon/AMT. Especially hard reflecting floors are the most common cause of sound lacking in soundstage and imaging. With more energy going sideways instead of up and down, the three dimensional soundstage is easier achievable. However, too much of this effect, also common for ribbon/AMT, will make it almost impossible to still enjoy the speaker at different listening heights, like while standing or moving around.

And there is more on tweeters and waveguides to be taken into consideration: soft domes have desirable dampening, but these domes can have also too severe “non-pistonc” behaviour. This can be as worse as the middle of the dome moving in the opposite direction while resonating. Furthermore, waveguides or lenses can suffer from uneven energy effects in the top octave because reflections of the sound waves here will resonate between its surfaces on opposite sides of the tweeter without a “phase plug” or dispersion cone to keep that from happening.

Back to the increased directivity of energy by a lens/waveguide/horn: too much of it can make sound a bit forward and compressed or even aggressive. In addition, there is the risk of taking too much away from the energy to the sides, sometimes resulting in a soundstage that lacks in width.



Aequo Audio made a tweeter system for the Ensis that has all the benefits of all worlds by getting a low distortion compact tweeter, into a controlled vertical/horizontal dispersion lens. And by doing so we automatically added the benefit of being able to place the vertically modestly sized tweeter closer to the midrange. Some designs only allow a good listening experience in the distant field because the drivers are too far apart however, EHDL™ equipped speakers sound great at virtually any distance. A dispersion cone was added to eliminate unwanted effects in the top octave, and also used to fix the middle of the dome tweeter section against resonance.

For the Stilla specifically, the acoustic lens was optimised by using fast 3D prototyping to make it work with even more demanding (smaller) rooms and to adjust time alignment of the slightly less tall speaker to best fit the various possible listening heights. Easy tilt adjustments completes all needed for the best stage in virtually any room.

With the Ensis renowned for its coherency, Aequo Audio was keen to duplicate this experience in the Stilla. Equipping a speaker with EHDL™ helps to potentially seamlessly integrate tweeter and mid frequency bands. However, it is the crossover filter that can still make or break the coherency. The importance of phase aligning and the minimum phase-shift only possible with acoustical first-order crossover filters, as is appreciated by enthusiasts and audiophiles alike, were all applied into the design of the Stilla.

The crossover filter performance and the components used were on a par with the Ensis and other premium speakers regardless of price. However, the passive filters of Ensis and Stilla have proved to excel beyond that in the extent of the frequency band for phase alignment, with Aequo Audio aligning both midrange and tweeter full range for the most discerning ears/brains.

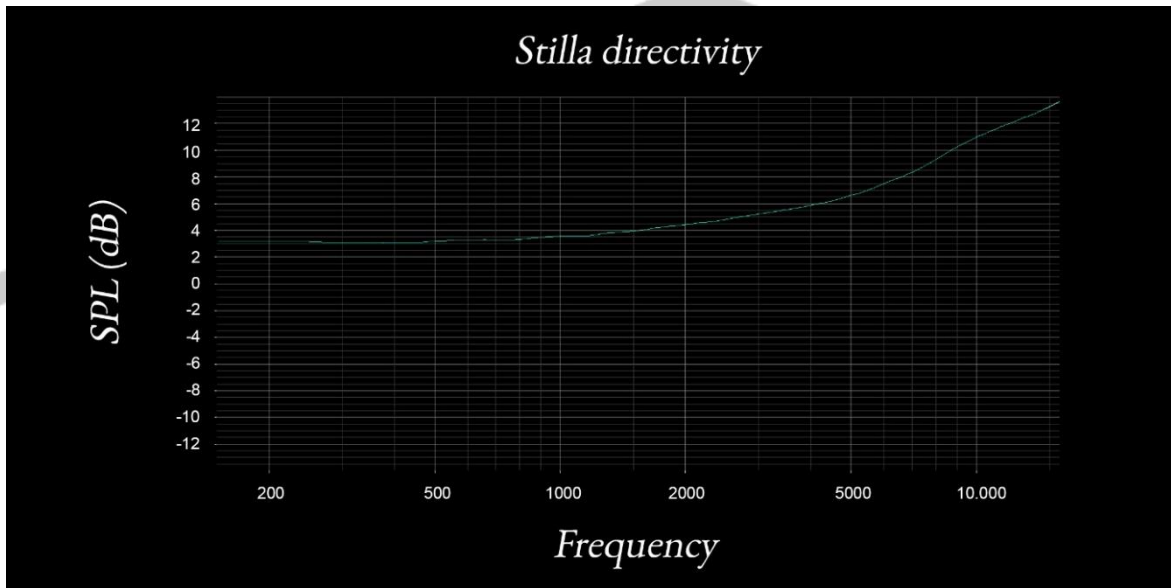


*Speaker driver phase measurement showing perfect time incident behaviour and both drivers moving together in perfect synchronisation in their movement over virtually all frequencies far beyond the crossover band around 2000hz.*

Aequo Audio created a three-way speaker that acted as a super-coherent, point-source-like speaker by incorporating aspects into the design that are often overlooked by other manufacturers. With regards to average dispersion in energy, both in the horizontal and vertical direction, it is imperative for coherence between drivers that an optimal directivity curve over frequency is delivered by both drivers working together.

To establish a holographic sound-stage that includes transporting the listener to the middle of the original recording venue, surrounding the listener with the original reverbs and decay effects, whilst providing realistic imaging between the speakers at any height and depth, the directivity curve must be almost unidirectional in the mid-frequency band to ensure the correct energy dispersion in a good room. There should be a very smooth rise in directivity towards high frequencies, which helps bundling the energy towards the listener to avoid excessive harsh sounding energy by reflection of these frequencies against hard room surfaces. However, in the top octave it should rise not too fast and have enough width and height left in the energy distribution for a fully open and airy stage from a large range of listening positions. The latter is often a problem with one or two-way designs using a “full range” driver for both mid and high frequency reproduction. Furthermore, for enhanced coherency, the directivity over frequency should be free of the jumps which are usually seen in multiple driver speakers. Taken all in consideration, The Stilla directivity, can be considered very close to perfect.

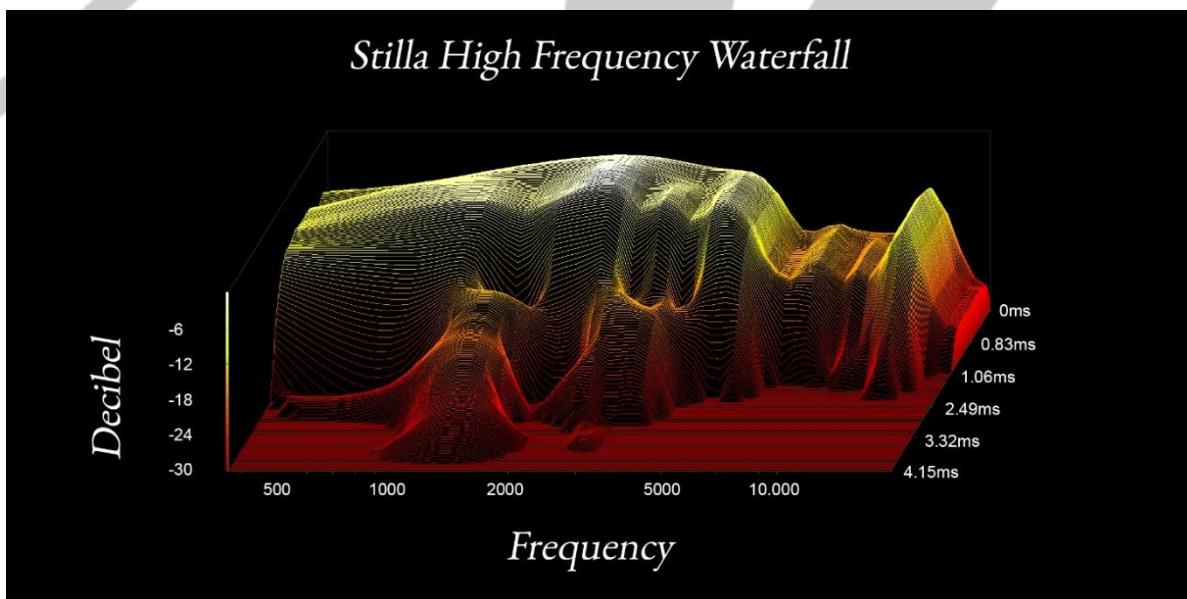




*Speaker directivity in db per frequency of Stilla. To attain the correct energy dispersion a good speaker stays within 3db below 3000hz, from the 3db base line (<6db), then starts bundling energy faster up to 8000-9000hz, then slowing its rate of energy-bundling again.*

Another important aspect that was taken into consideration by Aequo Audio in the design of Stilla was the time domain where acoustical energy is produced for the full audio spectrum. The team ensured that the Stilla was an extremely fast and open sounding speaker containing high-speed high-controlling motors on the self-dampening midrange and tweeter membranes with low amounts of stored energy. Graphically combining the measured output of two unfiltered drivers in a "waterfall" diagram, the transition of energy over frequency, with time of decay added, is a good tool for revealing potential coherency disturbing factors before applying the crossover filter.

It would be expected that from a 5 inch midrange driver there is some energy-storage in the 1-2k range by diffraction of its edges. Aequo Audio minimised this effect by choosing an optimal engineered shaped driver and, a cover in front of the midrange, close to the edges of the driver. Towards higher frequencies it is desired to have a nice decrease in stored energy without the further spiky energy storage effects caused by the ringing of hard cones or inverted resonant movement by the centre of soft dome tweeters. The Stilla is a fine example of very fast and coherent driver-behaviour in the time domain.



*CSD Waterfall diagram of combined mid and tweeter response data of the Stilla (blue line shows a gradual trend of decrease in stored energy towards higher frequencies)*

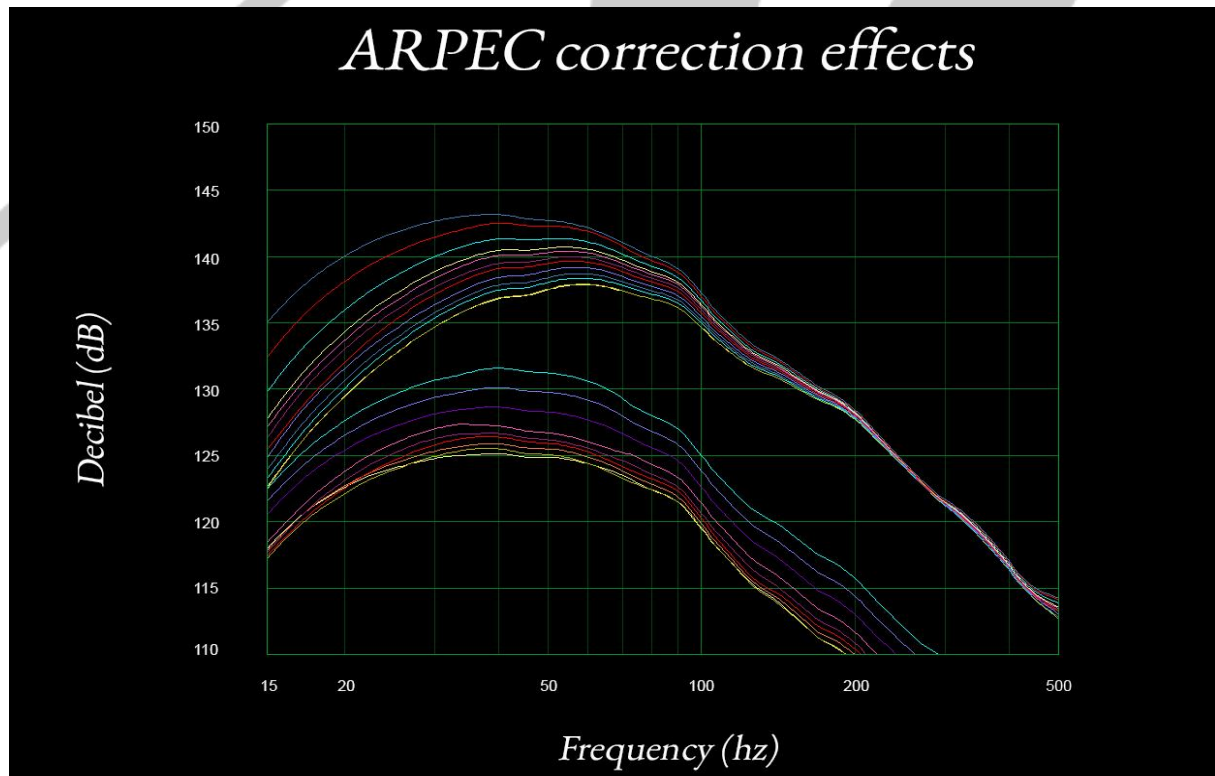
When the Ensis speaker was developed Aequo Audio were cognizant of the benefits of the fully analogue ARPEC™ system on compact closed box speakers. We made it get rid of unwanted behaviour from a big capable subwoofer driver in a very small enclosure, delivering the ultimate desirable roll-off regardless of cabinet size. It could also be used to tune this roll-off for different sized rooms along with placement near walls or corners as well as the ability to make individual speaker adjustments to overcome any asymmetry of the listening room's layout near the speakers. And all of that without the time delay, for computing time of the processor, or A/D losses inflicted by DSP solutions.

To meet the demands for the low frequency dynamics of the Stilla speaker, we were able to use ARPEC™ in a very new way: to tune a ported speaker to have the same ideal behaviour. Using the knowledge collected of ideal roll offs in various rooms and for various placement options, we applied the theoretical capabilities of our in-house developed ARPEC™ hardware, to get a very similar result to closed box speakers but with gained efficiency by adding the output of a port.

The port on the Stilla speaker is front loaded to stay away from front-wall inflicted “boomy” bass, whilst tuned so low that it produces frequency waves that are too big to fit in most, even large, rooms. The output from the port therefore works in the pressure domain, instead of the phase-time domain. Further acoustical down-sides of

normal ports, inflicted by the specific port roll off, were avoided in the audio band by mimicking a closed-box response. Finally, we angled the front port bass units to “roll” over the ground plane of the room towards the listener, extending the frequency band below 20hz whilst using a horn loaded tapered cavity over the total depth of the speaker thereby improving the aerodynamics of the port to eradicate compression effects and noise whilst also allowing the use of acoustic material for dampening any remaining scuffing or driver-motor sounds at excessive volume levels.

The double 7 inch subwoofers were Klippel-tested to prove how a smart, optimised finite element computer motor design with super linear control, a high quality Nomex paper cone and a low-loss super-linear excursion, could keep things effortless and clean up to extreme excursions, even exceeding the linear 12,5mm one way excursion of the Ensis subwoofer driver. To get the most out of these incredible powerhouses, the total power of the active amps was designed to match that of the Ensis, never falling short even in the most extreme conditions. These drivers were also fully vibration balanced by the smart placement of the first driver under 45 degrees, facing front and sideways, and then aligning a second one under it, also under 45 degrees, but facing to the opposed side of the speaker. This alleviated any sideways vibration and only backwards/frontwards directed vibrations were left which were then finally also dealt with by the innovative foot of the Stilla.



Measured close range, low frequency output at different ARPEC™ settings, of combined subwoofers/port output, showing a closed-box like roll-off and no dynamic compression at high output.

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## Conclusion

The musical subjective performance, as well as the measured performance of the new Stilla speaker makes a magnificent full-breed addition to the Aequo Audio stable. The whole team has worked tirelessly to successfully meet all the aspirations and demands of the products' development by using our existing technologies in similar ways as previously (eg. EHDL™) as well as by using them in totally new ways (ARPEC™). But, maybe even more importantly, by pioneering new avenues in the development and manufacturing of a compact, full range, high-end cabinet with the double 45 degree angled 7 inch subs cancelling out vibrations, the thermoforming of artificial stone under pressure, and also by evolving the Stilla's foot and utilising the special covered front baffle found in the Diluvium prototype. The Stilla will establish the Aequo Audio team's technical ability and know-how in the world of high-end Hi-Fi. Meanwhile Aequo Audio will continue to push all associated boundaries for the sake of music with all its magic, and for the inspiration of transporting the musical message into the hearts of many.

