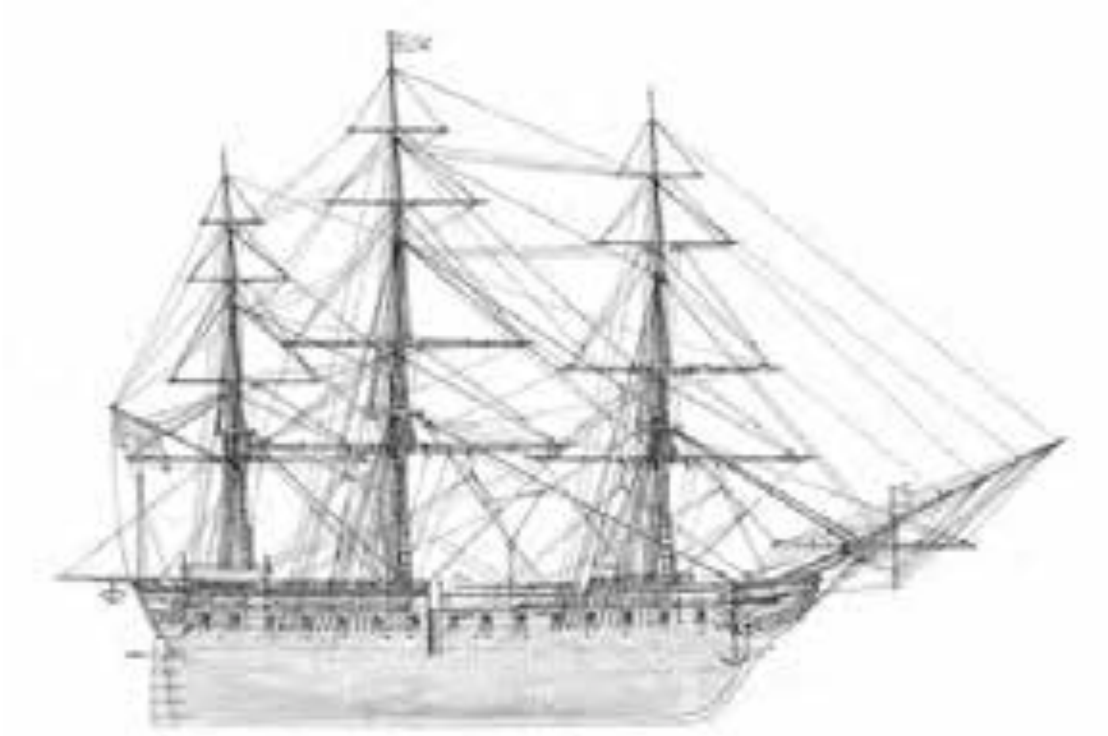
Wilson benesch
THE FUTURE IS CARBON



Endeavour

The Endeavour White Paper

April 2014
Wilson Benesch Ltd.
Falcon House, Limestone Cottage Lane
South Yorkshire
Sheffield
England

Wilson Benesch Directors, Craig Milnes & Christina Milnes with Head Design Engineers Gordon Farquhar & Alex Brennan outside the Wilson Benesch Headquarters

The Wilson Benesch Endeavour Loudspeaker
Celebrating 25-Years of Audio Innovation and Excellence

In June 2014 the Yorkshire based Audio innovator and loudspeaker manufacturer will celebrate its 25th-Anniversary and at the same time pay homage to the 250th-Anniversary of the launch of HMS Endeavour by naming its latest loudspeaker; Endeavour.

250-years ago on the month of June 1764 a ship, built by Yorkshireman Thomas Fishburn, was launched in the harbour of a small Yorkshire village called Whitby.

The HMS Endeavour would transport Captain Cook and his crew across the world and return them safely thanks not only to the design of the ship and extraordinary seamanship but also thanks to the state-of-the-art instruments aboard the HMS Endeavour which had been developed through the work of another Yorkshireman, the great Horologist John Harrison. Harrison solved the problem of the age, by developing the marine chronometer that allowed for the accurate measurement of longitude.

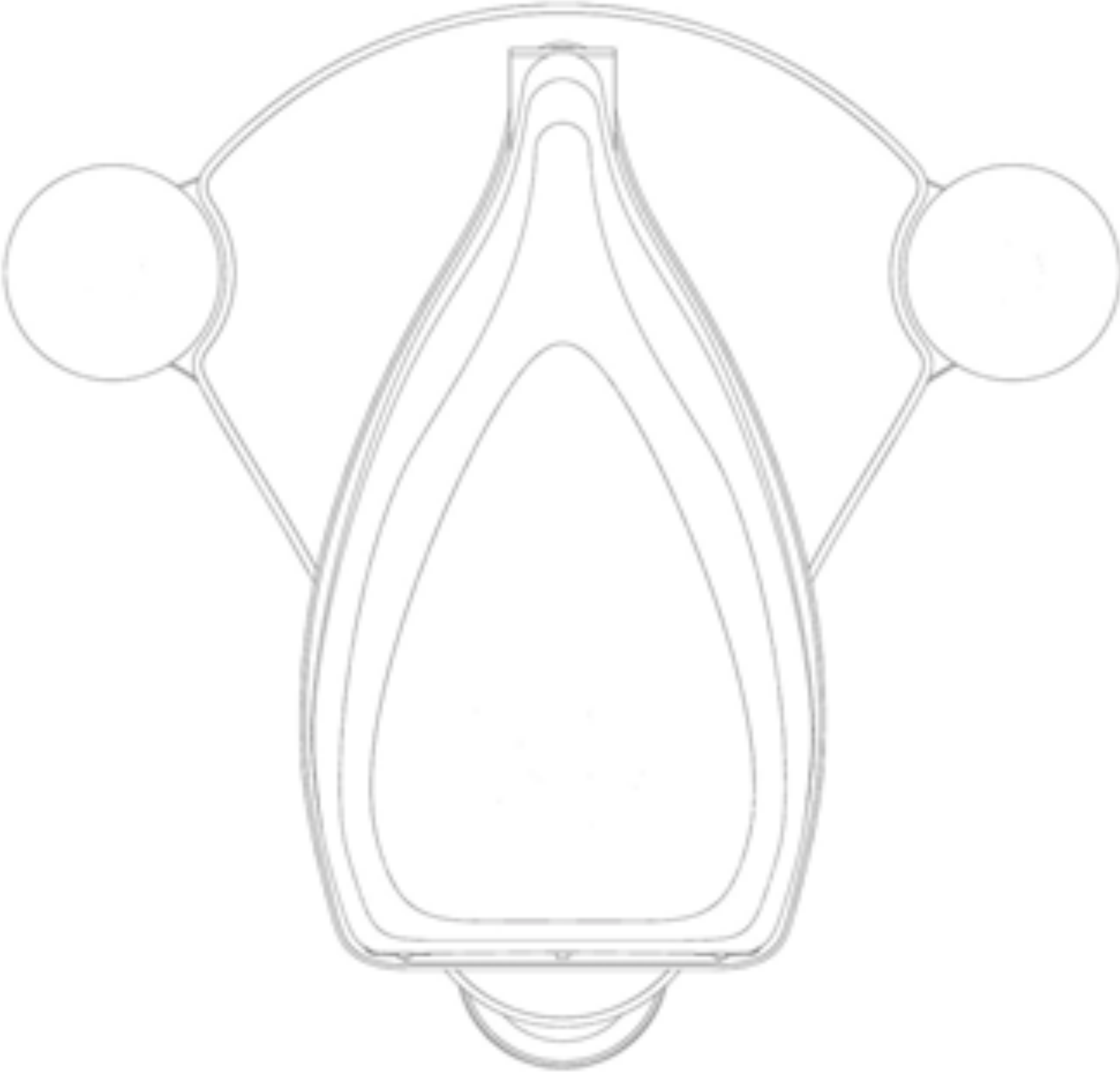
As part of our own anniversary celebration we tip our hats in recognition of the great achievements and historical importance of the Yorkshire and indeed British engineers and craftsmen of 250-years ago. These are people who should be celebrated and remembered for their ingenuity, engineering prowess, bravery and un-waivering commitment to exploration and invention.

These are the true heroes that shaped the world that we enjoy today.

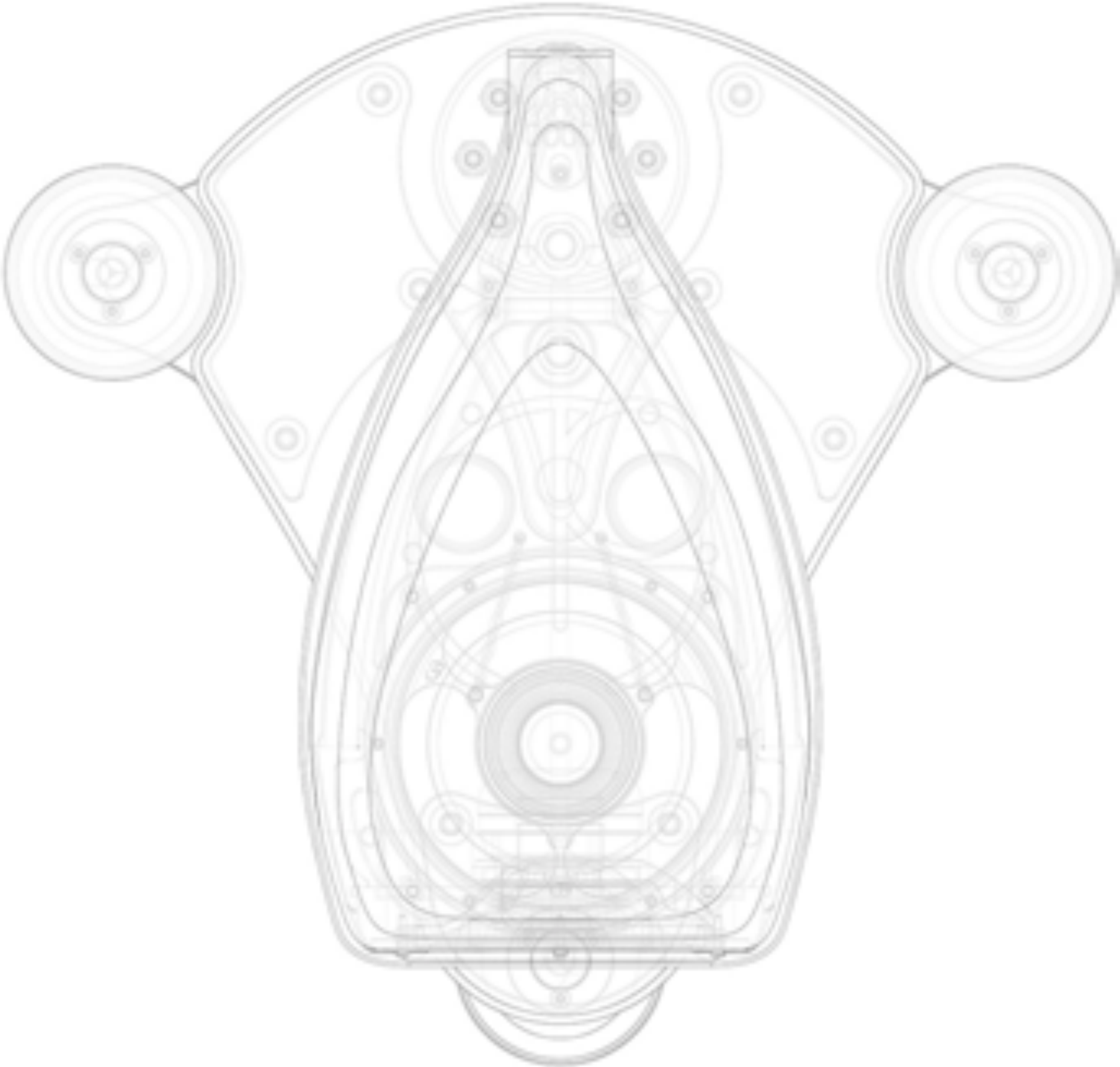
Craig Milnes
Design Director

Christina Milnes
Managing Director

Conceived



Developed



Manufactured

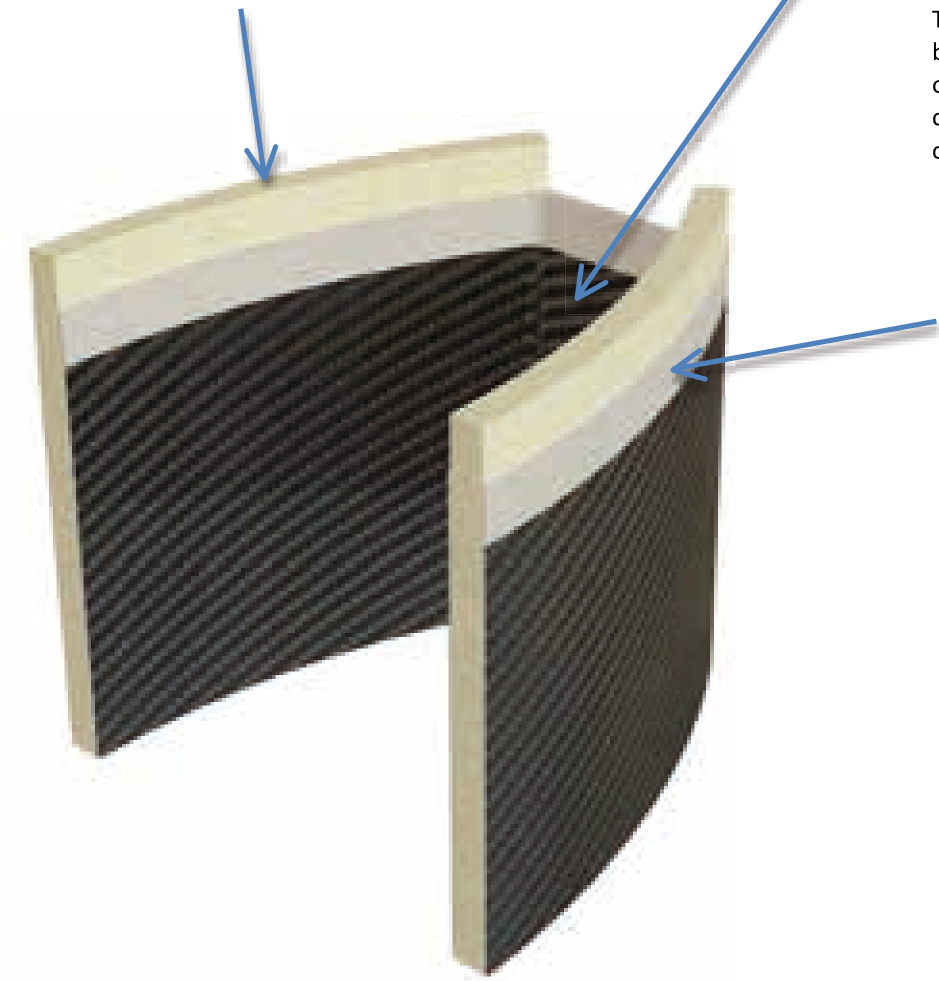
&

Assembled

The foundations of the Ultimate Loudspeaker
The A.C.T. Monocoque

Aerospace high compression core comprised of an alveolar like structure with billions of air pockets. This complex structure is deployed in the luggage holds of passenger airliners to mitigate against blast energy. The material creates a super high compression core for the I-section.

Similar structures can be found in the McLaren P1 Monocoque, Formula 1 racing cars, and many other high performance systems.



Aerospace grade carbon fibre based composites liberate the designer and provide for a completely different approach to loudspeaker design.

In an A.C.T. structure, the carbon fibre is spaced apart by the core, to exploit the advantages of a curved geometric form whilst pairing two high tensile skins, spaced apart by a high compression core.

The manufacturing systems that have been developed by Wilson Benesch in order to realise this technology are high cost and completely unique to the company.

Glass fibre is markedly weaker than carbon fibre, but it does make a small contribution to the strength of the final structure.

The principal reason for including this additional layer, is to significantly elevate the damping capacity of the monocoque structure. It is the combined effect of the three materials which form a composite and this is the key to attaining unrivaled loudspeaker performance using the A.C.T. monocoque.

History Behind the A.C.T. Monocoque
The highly optimised arch geometry is an elegant solution, that was developed in collaboration with PERA, a government organization. In 1999, when Wilson Benesch started to manufacture carbon composites using Advanced Resin Transfer Mould Technology, it was one of just four establishments in the UK using the technology. Of the other three, one was Lotus Cars, the other two M.O.D. Research Facilities.

A.C.T. Monocoque
Advanced Composite Technology

If the sophisticated A.C.T. monocoque structure was judged by purely engineering function, it would lay claim to being one of the worlds lightest, stiffest and most highly damped structures ever manufactured. In terms of energy damping and therefore signal-to-noise ratio, it would exceed with consummate ease the traditional conventional materials typically seen in loudspeaker design to date.

The A.C.T. Monocoque has been engineered and optimised for its critical role in audio reproduction:

1. **Composite Structure;** Its composite three-layer structure vastly improves the damping property of carbon fibre reinforced plastic (CFRP). The combination of the blast core, carbon fibre and glass fibre creates a composite monocoque with the stiffness of CFRP and the damping properties of the blast core.

2. **Fibre orientation;** a single toll of carbon fibre consists of billions of microscopic fibres, 1,50,000th the diameter of a human hair. Each fibre presents a boundary between escaping energy inside the loudspeaker cabinet and the listening environment. Furthermore, these fibres are arranged in a regular fashion. The discernible fibrous weave in the A.C.T. Monocoque allows the energy being absorbed by the structure to flow directionally along the weave into the viscoelastic seals which bond the aluminium structures in the speaker.

3. **Sound transmission;** because of the directional flow of energy down the regular weave and fibres in a carbon composite structure, the velocity of transmission of this energy is greater than any conventional material. This provides the designer with a significant advantage, allowing the small amount of unwanted sound energy escaping from the loudspeaker cabinet to occur as close as possible to the original sound made by the drive units in the loudspeaker. This avoids unpleasant overhang in a musical performance.

4. **Geometrically optimised;** the perfect curvature disperses sound energy both internally and externally evenly across its surface. This is critically important in loudspeaker cabinet design. It eradicates what audio engineers term *standing waves*. This inhibits the ability of the listener to easily locate one point of diffraction, so the loudspeaker cabinet remains silent.

5. **High Resonant Frequency;** every object has a natural resonant frequency. Stiff - light structures naturally have a high resonant frequency, where compliant - heavy structures have a low resonant frequency. High frequencies are easily damped, where low frequencies are very problematic and cannot easily be damped. In the Endeavour, structures with a high resonant frequency such as the A.C.T. Monocoque and the aluminium structures are damped using visco-elastic seals, which can easily absorb any high resonant frequencies.

Cabinet Design in the 21st Century

The image below provides a simple comparison between two structures with the same air volume and the same stiffness. The image illustrates the huge difference in the relative size and weight of the two structures in order for each to achieve the same design goal.

The design limitations of MDF indicate that they are inappropriate for use in loudspeaker cabinets aspiring to be the ultimate solution.

Replacing MDF with aluminium is improves stiffness, however aluminum exhibits very poor self damping, the result would be a highly resonant structure. In order to control resonance in designs based around aluminium, elaborate and complex bracing is deployed, which in turn subtracts from the air volume of the internal cabinet, a major loudspeaker design compromise.

Key Concepts
All cabinet structures resonate and emit sound.

Mass
High Mass = Low Resonant Frequency = High Cabinet Noise
Low Mass = High Resonant Frequency = Low Cabinet Noise

Resonant Frequencies
Low Resonant Frequencies are easily damped.
High Resonant Frequencies are difficult to damp.

Surface Area
If a loudspeaker cabinet has 100 times the surface area of the drive unit diaphragm it only has to move (resonate) 100th the amount of that diaphragm to produce the same output.
So it follows, large cabinets are inherently less stealth like and silent.

The Composites Age

Wilson Benesch pioneered the use of carbon fibre composite structures in audio design. The company now has more than 20-years experience and intellectual property, relating to the exploitation of this important field of engineering.

It goes without saying that this wonder material has revolutionised the automobile industry, aerospace industry and sports equipment industry to name a few. Countless examples can be seen from the McLaren P1, to the Boeing 787 Dreamliner, or to Sir Bradley Wiggins's incredibly stiff, lightweight carbon fibre bicycle used to win the Tour de France.

In each case the unrivalled stiffness, strength and the phenomenal weight advantage that carbon fibre composites have provided that has allowed these designs to become a reality. But of course, the inherent property of carbon fibre composites, which is key to Wilson Benesch designs such as the Endeavour, is the phenomenal damping properties of these composite structures and the ability to channel and manage energy flow in one single structure.

Perhaps the best 'real world' example of this property is in Formula 1 car design. Here carbon fibre structures have been subjected to the most public demonstrations of the phenomenal capacity of this material to absorb huge amounts of energy, whilst remaining largely intact in order to protect the driver in the car. Today there are countless drivers who owe their life to this material. They are the stiffest most highly damped structures known to man.

Mercedes F1 W05: the fastest F1 car in the 2014 Formula One World Championship (at the time of publication)

Mutual Self Damping:
Aerospace Engineering Materials

damp·ing
noun *Physics.*
1. a decreasing of the amplitude of an electrical or mechanical wave.
2. an energy-absorbing mechanism or resistance circuit causing this decrease.
3. a reduction in the amplitude of an oscillation or vibration as a result of energy being dissipated as heat.

The concept of mutual self damping is central to any high performance engineering system, especially those where a high degree of control over the structures behavior is concerned. A rudimentary example would be the use of the fingers in stringed instruments to control the vibration in strings and so changing the sound the instrument makes.

Mutual self damping is based on the energy absorbing potential (damping ratio), of two quite different materials which are brought together. When the materials are disturbed from their static equilibrium, the resonant frequencies of each material act upon each other and reduce or stop completely, one and the others resonance – the mutually self damp one another.

The image below shows one such example of a resonating glass, being damped by the finger. This is identical to the percussionist, damping the cymbal by grabbing it.

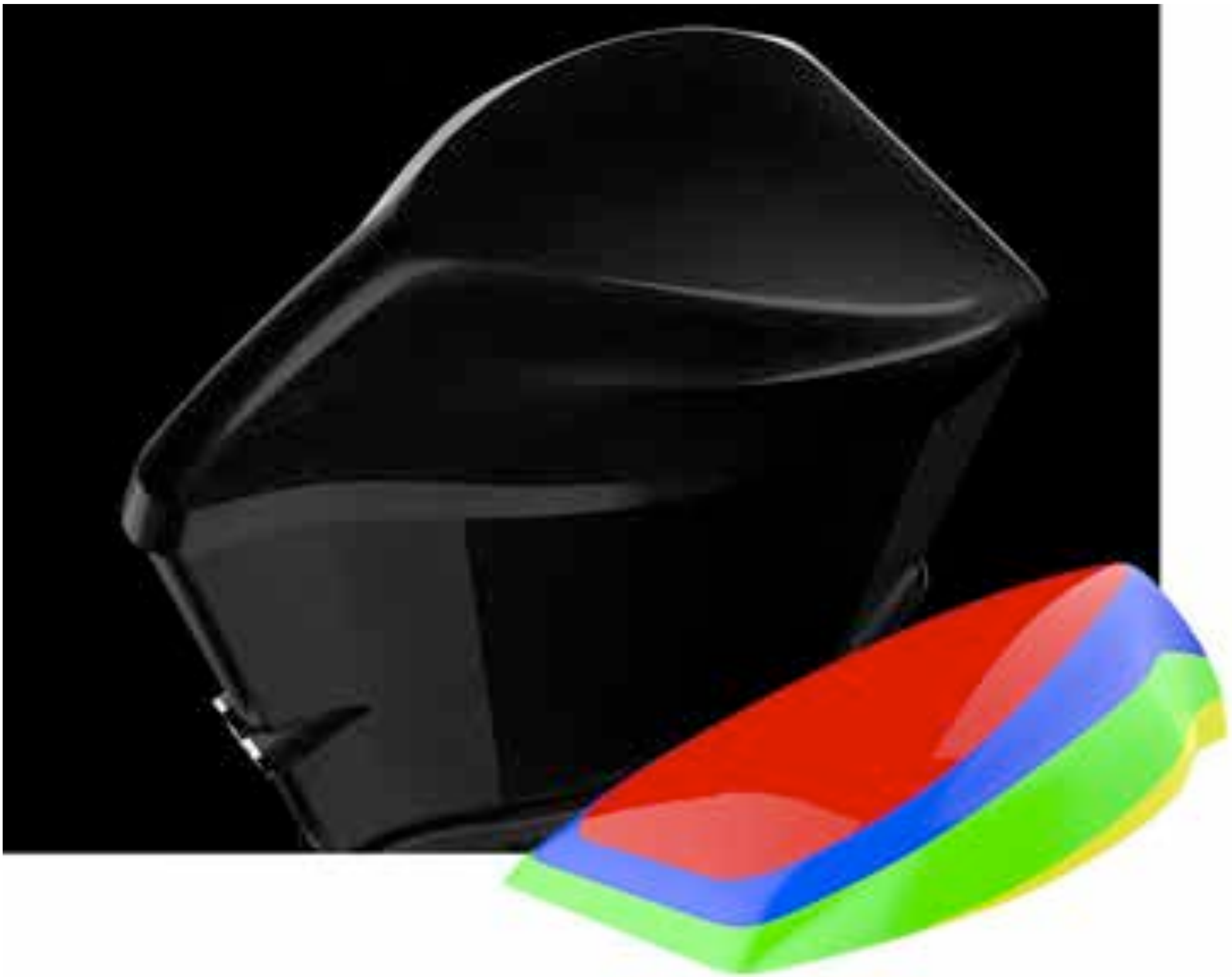
Wilson Benesch exploit mutual self damping through the use of aerospace engineering materials. The carbon composite A.C.T. structure, which is mutually self damped in its own right, is combined with the aluminium baffle, spine and bass board. The carbon composite structure legislates for the use of aluminium, a (relatively) poor damping material, by damping the aluminium before it is excited by the energy born from the loudspeakers drive units.

Wilson Benesch: The History of Mutual Self Damping
In 1994 Wilson Benesch announced the A.C.T. One Loudspeaker. At the time the design was radically different from anything that had been seen before in the high end audio market.

Unlike the single material, recti-linear MDF box designs of the day, the A.C.T. One consisted of a curved carbon composite chassis. But the success of the design was based on the use of no fewer than five different materials, including hard wood, MDF, aluminium, steel and of course the A.C.T. composite.

3D Parametric Design

The Endeavour features a beautifully sculptural carbon composite top. Whilst a very natural, organic form, based on curves and free flowing lines, the shape is an extremely complex 3D structure that has been optimised using powerful 3D Parametric Computer Design software.



Like the Cardinal, the Endeavour top evolved from sketches to full sized clay and wax sculptured forms. The wax model has then been extensively modelled in a digital 3D space using a 3D laser scanner. The data is placed into a 3D design package and the complex forms are then refined further, creating a symmetrical structure down medial plane.

This method is akin to reverse engineering, but the advanced engineering software available to Wilson Benesch provides a unique and highly efficient workflow. Were it not for the 3D laser scanner and the engineering excellence that exists within the Wilson Benesch design team, the Endeavour and indeed the Cardinal carbon composite top would not be conceivable.

Such highly engineered, sculptural structures are exclusively the preserve of high performance products or architectural forms. The Endeavour top is therefore a testament to the significant design and engineering excellence that pertains at Wilson Benesch, it is the hallmark of a true high end, luxury audio product.

Stealth;

Mastering Reflection, Refraction and Diffraction

Stealth Structure

Stealth
n
1. (Aeronautics) (*modifier*) denoting or referring to technology that aims to reduce the radar, thermal, and acoustic recognisability of aircraft and missiles

The Royal Albert Hall, London: Large fiberglass acoustic diffusing discs in the roof remove the echo from the Albert Hall. Prior to their installation in 1969, it was said that the hall was the only place where a British composer could be sure of hearing his work twice.

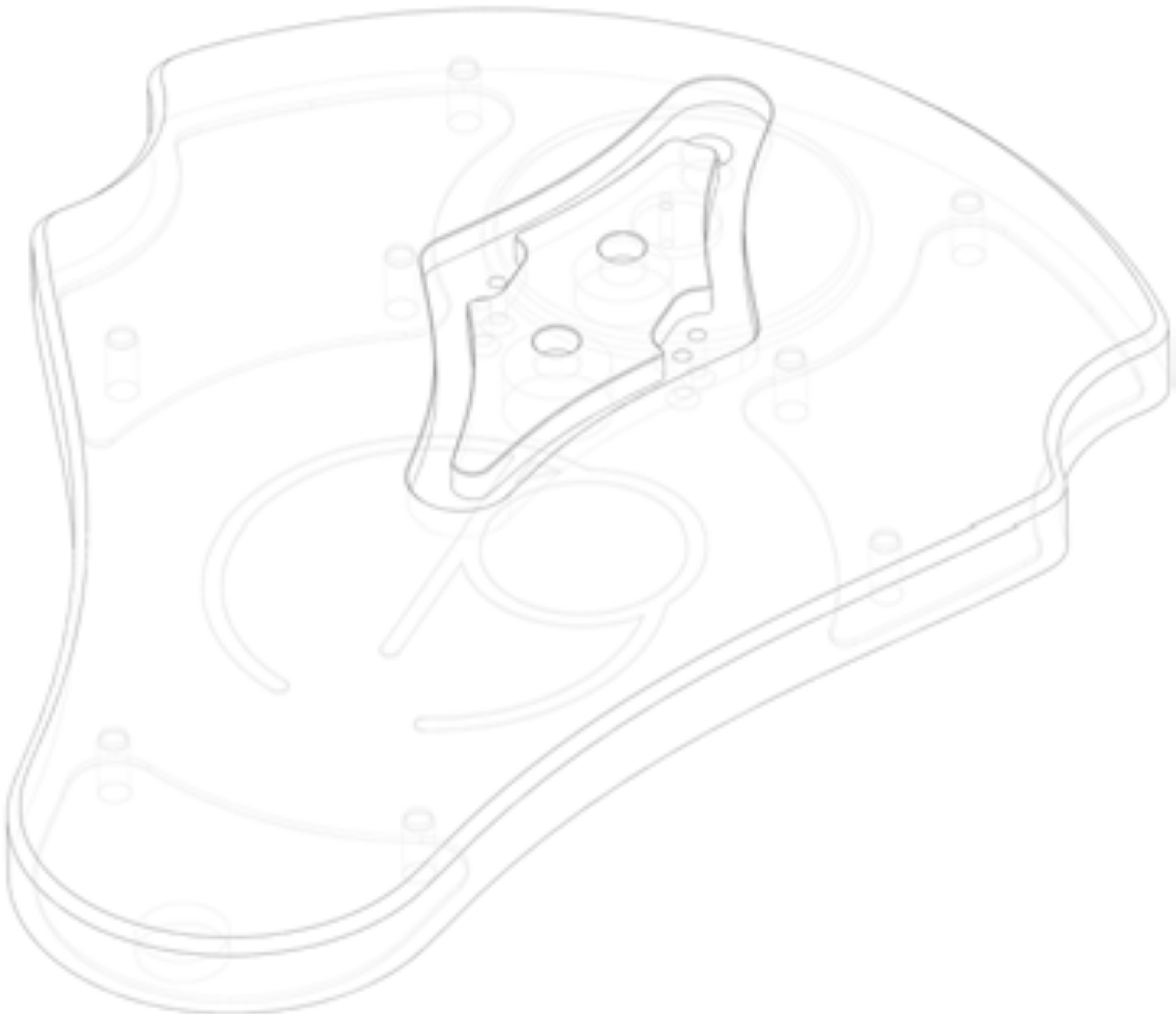
When a longitudinal sound wave strikes a flat surface, sound is reflected in a coherent manner provided that the dimension of the reflective surface is large compared to the wavelength of the sound. However, the reflective nature of a structure varies according to the shape of the surface. Uneven surfaces will tend to scatter energy, rather than reflect it coherently.

In good design, form always follows function. So whilst the Endeavour top is a beautiful structure, its complex 'stealth like' form is critical to the performance of the loudspeaker. By removing any flat, reflective surfaces and creating a highly complex structure, any reflective sound energy is scattered. This diminishes its energy and also avoids standing wave patterns within the listening space that are easily detected by the human ear as distortion or colouration.

The Endeavour owes much of its phenomenal capacity to present a spatial soundstage and transparent imaging, to the curved carbon composite forms of the top and the A.C.T. monocoque. The loudspeaker stealthily disappears within the listening space, leaving an ethereal soundstage and lifelike presentation.

The Endeavour Foot

One of the most important principles in structural engineering is loading. All modern buildings are built upon solid foundations. It is the reference point for everything above it, transferring the load of the structure into the ground and anchoring the structure to the ground, which is crucial in loudspeaker design to create a stable point from which the drive units can propagate complex and accurate waveforms that we appreciate as music.



The Endeavour foot is comprised of multiple components. The main foot is machined from a 40kg slab of high-grade aluminium alloy, which is then combined with two extension plates that are bolted to the main structure via three high tensile bolts. Add hand-wheels and the spikes; all design and manufactured in-house at Wilson Benesch and the whole foot assembly weighs in at well over 30kg.

Complete with a silk black rubberised aerospace finish just as with the Cardinal; this is F1 fit and finish, no compromise.

Ground up Optimisation: Kinematic Location

At over 100kg per channel, the Endeavour is a substantial structure. Housing a Tactic-II midrange drive unit and a powerful Tactic-II Isobaric Drive System, it is also a phenomenally powerful loudspeaker. The importance of high integrity stabilisation is critical, if the micro-dynamic performance of the loudspeaker is to be maintained.

The Endeavour’s colossal foot extends outwards to increase the base area where upon three 28mm, steel threads take up the mass of the Endeavour. The load and any energy is then reduced into just one 12.5mm steel ball.

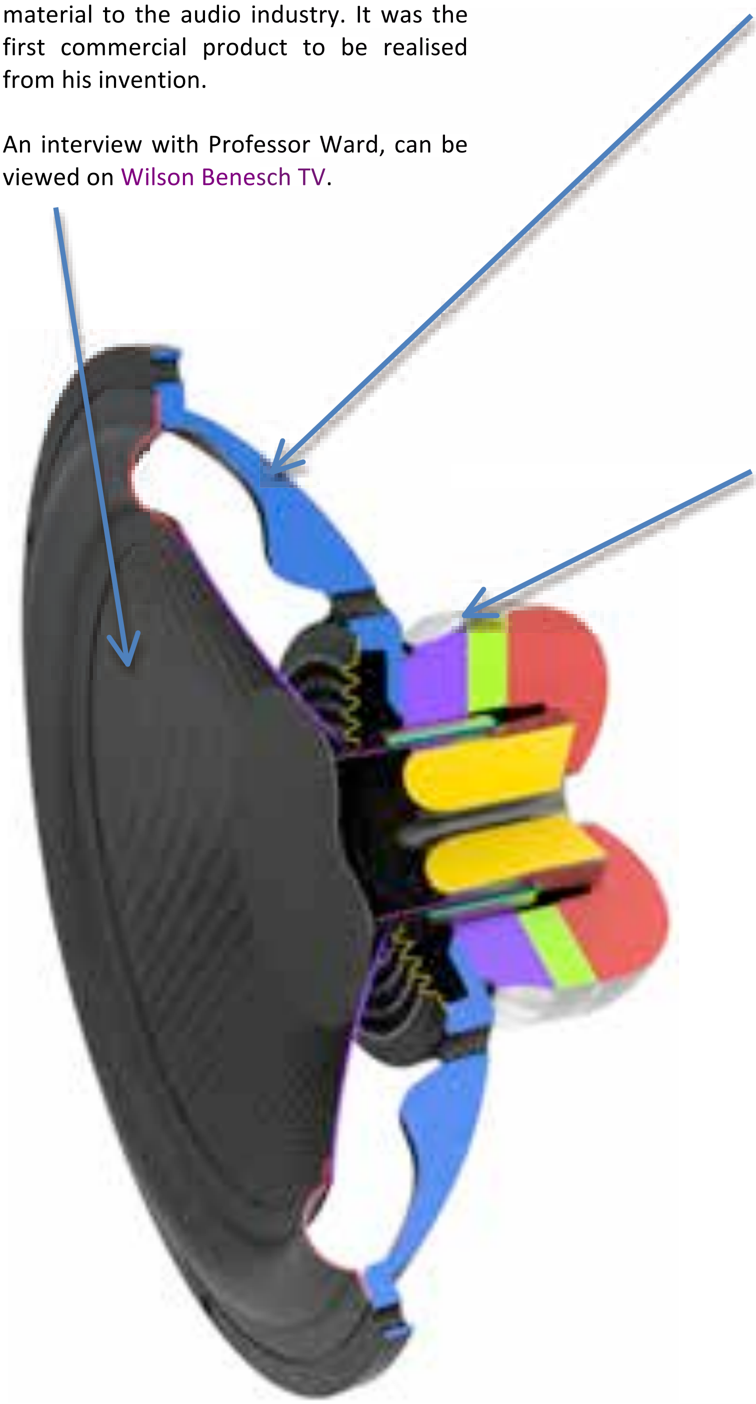
This design ensures that the point at which the Endeavour’s entire mass loads into the floor is measured in hundreds of tons per square inch, as the entire mass of the system is focussed in upon less than 1 square mm of surface area.

Tactic II Drive Unit

When Wilson Benesch introduced the original multirole *Tactic Drive Unit* in 2001, it was the first drive unit in the market to utilise the incredible magnetic power of NdFeB or rare earth magnet. Now more widely used in high end drive unit designs, but by no means industry standard owing to the very high cost of the material, NdFeB is the most powerful commercially available magnet available.

Isotactic Polypropylene was invented by Professor Ward of Leeds University. Wilson Benesch collaborated with the professor to introduce this superb material to the audio industry. It was the first commercial product to be realised from his invention.

An interview with Professor Ward, can be viewed on Wilson Benesch TV.



High pressure die cast basket delivers the ultimate window for energy to exit the rear surface of the diaphragm. Its reductive, streamline geometry affords the design a lot of stiffness, whilst minimizing any obstruction to airflow in the highly pressurized zone to the rear of the drive unit.

The curvaceous motor structure is manufactured in house on high precision CNC machines. Through collaboration with the Sheffield Hallam University, Wilson Benesch have been able to perform complex flux analysis across the structure. Every line of flux is fully optimised to extract the maximum power from the magnet.

It has been in part due to the latest flux analysis software that Wilson Benesch has been able to increase the power output of the Tactic II by 2dB.

A film has been produced on the manufacture of the motor parts which can be viewed on Wilson Benesch TV

History behind the Tactic II

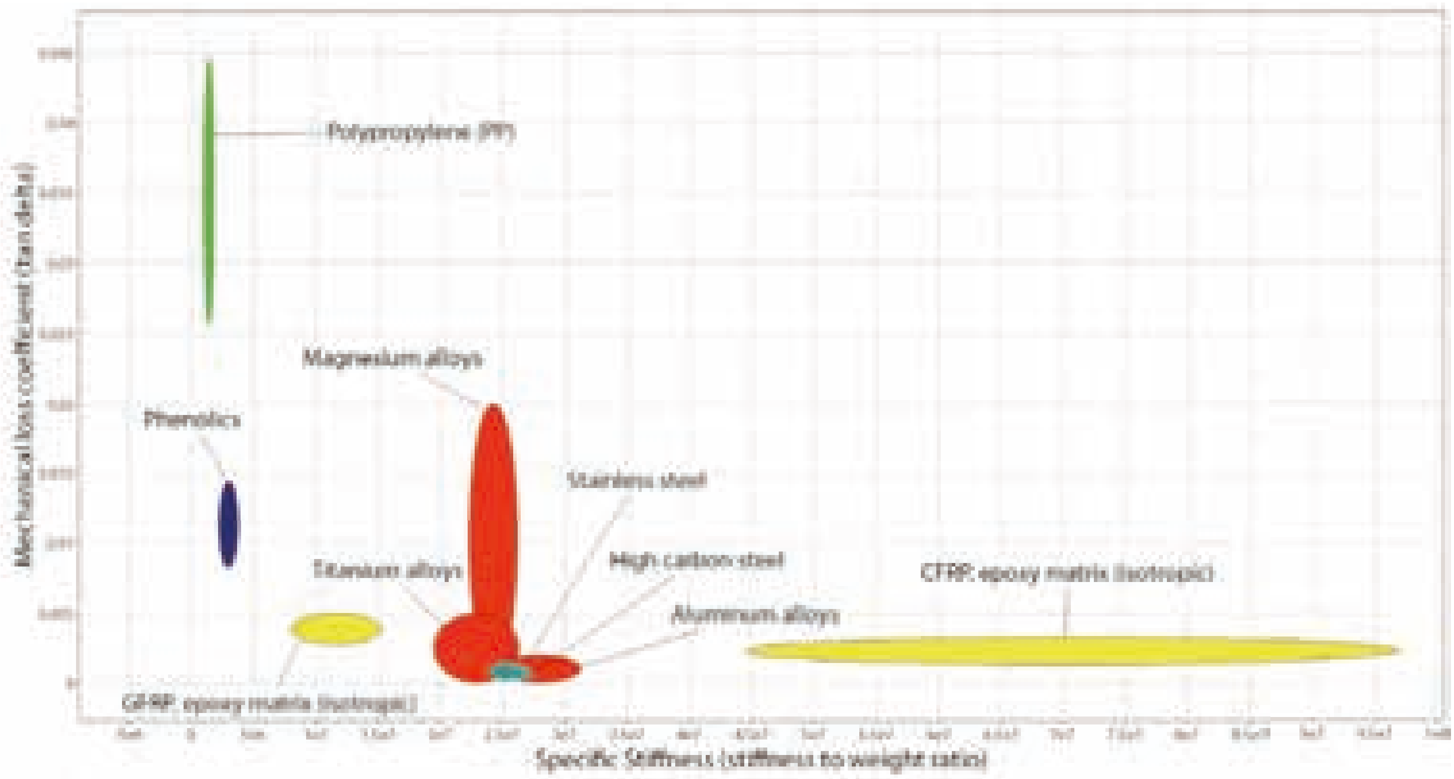
The Tactic drive unit came out of the Bishop Project that began in 1999. The £130,000 research project was part funded by the D.T.I of the U.K. Government via the S.M.A.R.T. research and development program.

The principle focus of the project, was to develop a multi role drive unit. Another key objective was driven by the need to improve the step response of low frequency drive units through a radical re-interpretation of the French invention, the Isobaric.

Isotactic Polypropylene (IPP)

Underpinning the Wilson Benesch design philosophy is science; in engineering and the application of the basic physical laws that govern the universe. Since the foundation of the company in 1989, advanced materials technology has consistently led our extensive R&D programmes and much of our product development has hinged around one wonder material or another.

Isotactic Polypropylene was developed by Professor Ian Ward. Isotactic literally means, “of equal inclination” and refers to the repeating, regularly spaced methyl group on the backbone of the chain within IPP chemical structure allowing the macromolecules to coil into a helical shape. It is this chemical property that makes IPP the most suitable choice for a high end drive unit design.



The graph above compares the degree to which a material damps vibrational energy (mechanical loss coefficient) and its stiffness to weight ratio. Whilst polypropylene has a relatively low stiffness to weight ratio, it has excellent ability to damp vibrational energy. Woven Isotactic Polypropylene is infact five times stiffer and better damped than the homogenous polypropylene shown in the graph above.

When subjected to audio frequencies a drive unit diaphragm moves in and out to create sound waves at different frequencies that produce a musical piece. However the timbre, quality and clarity of the sound produced has a direct relationship to the material used to create the sound.

Wilson Benesch rejected carbon fibre diaphragms made from a carbon fibre / epoxy matrix, after trials undertaken in 1995. Further research has been conducted using alternative hard dome materials. Without exception the highly engineered, highly optimised Tactic Drive Unit accompanied by IPP was chosen for its natural sound and none sibilant sound character.

Tactic II Isobaric Drive

To the underside of the Endeavour, two Tactic II Drive Units combine to create an Isobaric Tactic Drive.

The Isotactic Drive is responsible for reproducing incredibly tight and controlled bass response that is perfectly integrated with the midrange Tactic II drive unit.

There are no transient delays in nature. So it should come as no surprise, that transducers that exhibit the fastest transient response come closer to reproducing natural sound more accurately. This has been a guiding principle in all Wilson Benesch drive unit development.

The basic Laws of Physics dictate that a large woofer will never function with the speed and dynamics of a small drive unit. It for this reason that Wilson Benesch ruled out the idea of using large, slow woofers in loudspeaker design.

Such drive units cannot accelerate or decelerate quickly enough to reproduce the sound and energy of a musical performance faithfully. To accept such a compromise would be to accept energy propagation that could never be described as integrated. With large woofers, the foundations of the entire sound scape are compromised by retarded dynamic response both in terms of step response and system recovery.

The key facts about exactly why the isobaric is the ultimate solution for generating bass might be obvious from the adjacent image. However, for your scrutiny, the next page contains a summary.

A brief summary of the principle benefits of the Isobaric system

• Super stiff / super low mass diaphragm. The air link between the two diaphragms can be seen as a composite structure with outstanding stiffness to weight ratios. No other known drive unit diaphragm can aspire to possess such properties.

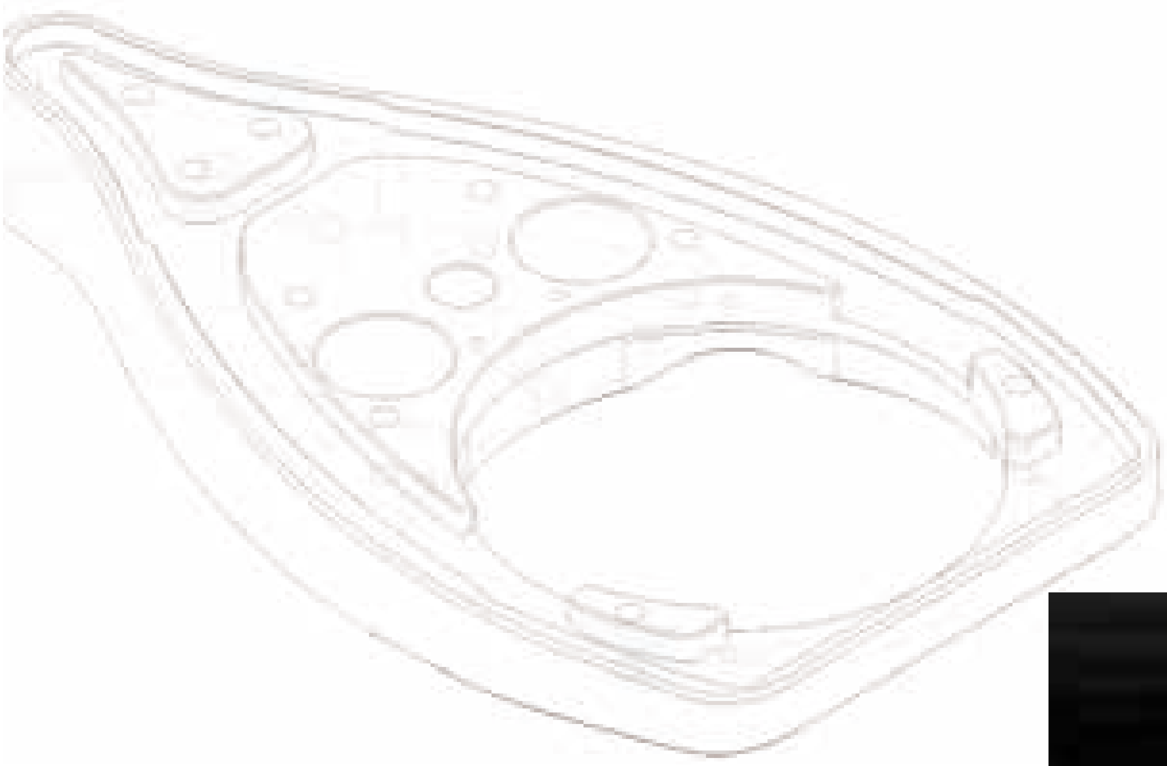
• The complexity of the isobaric virtually eliminates cabinet noise. First of all imagine a conventional large cone loudspeaker design. Now remove from the design the diaphragm and imagine now what you see. A hole that looks more like a washing machine! So after working so hard to build a massive structure we are asked to ignore this huge hole, this window to noise. Even complex membranes pose little or no barrier to noise that has a direct path to the listener. This simple physical fact is why Wilson Benesch has never used a conventional diaphragm or large drive unit.

• To achieve the same bass extension, a conventional design would require double the air volume. A larger box means more noise. No one can argue with this. The ability of the enclosure to achieve any Stealth qualities is also severely undermined.

• The drive unit that you hear, has no spring effect on it. The drive unit inside the enclosure moves all aspects of the air volume and so the spring effect. The drive unit you hear sees only a single pressure the same as free space. The resonant frequency is as a result, very low. This low resonant frequency could only be achieved in a conventional system by adding mass, at least double. The consequence is a total loss of dynamics and transient performance. Much has been written about the integration of sound between drive units. Conventional design admits defeat at the outset. With the isobaric design, the bass is in fact faster in terms of its step response than the mid range!

• Large drive units are inherently unresponsive. You cannot accelerate and decelerate a large heavy car, like you can a small nimble car. Basic physics tells us this. In large woofers, it is only convenience and cost that are the main benefits. For this you pay the price of poor step response and overhang. You also suffer a character of sound that is completely different to the other dive units that it is expected to integrate with.

Engineering Excellence: The Endeavour Base Board



The form of the large aluminum base plate at the bottom of the A.C.T. Monocoque gives a sense of the highly engineered structure that resides beneath. However the precision CNC machined 4kg mass is a very impressive structure that houses the carbon fibre port tubes and the powerful Isobaric Drive. It also houses the A.C.T. Monocoque, side cheeks, spine and the baffle.

Its curved form presents a mass of unyielding stiff aluminium, from which the high precision Tactic II Drive units and Semisphere Tweeter can operate.

Air Volume: The Wilson Benesch Carbon-Nanotech Enclosure

Whilst the Endeavour is ground breaking in many respects, its crowning achievement might well lay directly behind the midrange drive unit. The Endeavour introduces the world's first Carbon-Nanotube enhanced carbon composite midrange bell housing. Born from research carried out in partnership with the Advanced Manufacturing Research Centre in Sheffield. The Carbon-Nanotech Enclosure is a huge breakthrough in high performance loudspeaker design.

This extra-ordinary structure bestows the following key benefits:

1. Optimal Midrange Air Volume: By partitioning the air volume available exclusively for the midrange drive unit. This critical drive unit, which produces the frequencies within the bandwidth most sensitive to the human ear, is free to work in isolation of the Isobaric Drive. Significant improvements in the midrange dynamics can be achieved as the drive unit no longer competes with the far more powerful Isobaric Drive.

2. Optimal Isobaric Air Volume: In order to achieve powerful, dynamic and low bass frequencies, the bass drive units require a large air volume within the speaker cabinet.

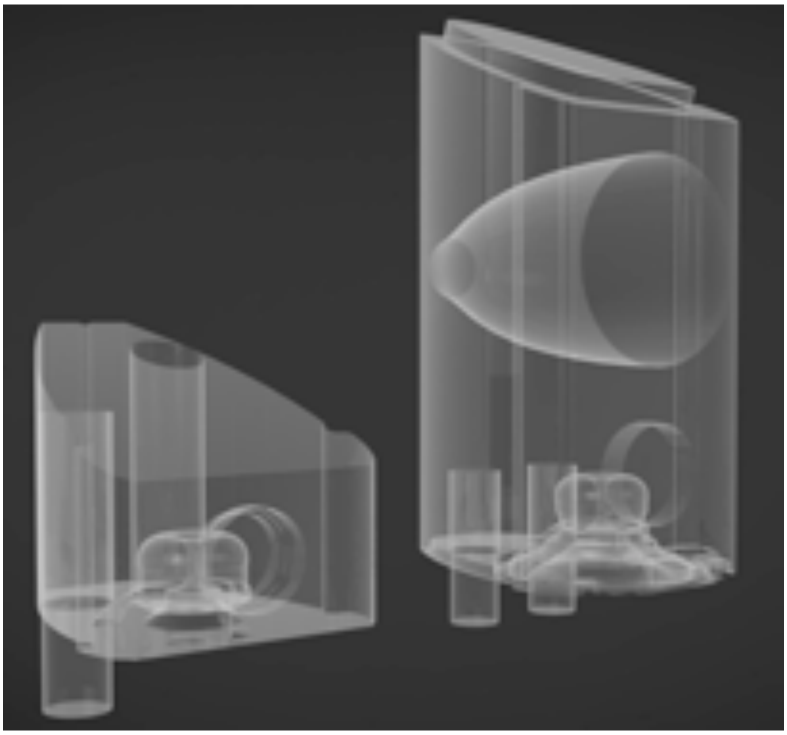
Due to the phenomenal stiffness of the A.C.T. monocoque, Wilson Benesch loudspeakers are releatively free from complex internal bracing found in other designs which subtract from the critical internal air volume.

By isolating the midrange to its own optimised enclosure, Wilson Benesch have significantly increased the air volume afforded to the Isobaric Drive even further.

The image on the right illustrates the total air volume available to the Isobaric Drive in two design options.

Looking at the illustration on the left, which is based on the conventional idea of simply dividing the cabinet in half for bass and midrange units, it can be appreciated that the total air volume afforded to the Isobaric Drive is very small.

Now looking at the right illustration, we can see that the Carbon-Nanotech Enclosure has isolated the midrange and allowed the remainder of the cabinet around the enclosure, including the space at the top of the cabinet for the Isobaric Drive.



3. Optimal Energy Control: The Carbon-Nanotech Enclosure isolates the midrange drive unit and its effective 'open window' to the listening room from the energy generated inside the cabinet. The Carbon-Nanotech Enclosure is phenomenally well damped, so by adding what is effectively a second composite structure to damp and control out of phase energy within the cabinet, the noise floor is lowered to a new level within the frequency range most sensitive to the human ear. The midrange presentation has a clarity and composure that is beyond previous benchmarks.

4. Optimal Integration: Low frequency energy is delivered by the vertically orientated Tactic II Isoabric Drive that places the voice coils in virtually the same plane as the Tactic II midrange drive unit. This configuration ensures near perfect time alignment with the lowest level of diffraction. Being vertically orientated ensures that no structural displacement occurs even at the highest levels.

5. Optimal Geometry: It is no coincidence that the geometry of the Carbon-Nanotech Enclosure closely resembles that of a classic champagne bottle. The curved structure has a proven ability to cope with enormous pressures.

6. Optimal Material Application: With the numerable critical design goals of the Carbon-Nanotech enclosure, only the most advanced materials technology could be applied to achieve these.

As the structure is placed internally, the aesthetic concerns associated with the A.C.T. Monocoque are largely superfluous, so it has been possible to deploy aerospace quality pre-preg carbon fibre, combined with the strongest material known to man, carbon nanotubes.

By adding carbon nanotubes to the resin matrix it is possible to attain improvements in damping and stiffness that is almost 5x that of similar structures without carbon nanotubes. In terms of the stiffness, the Carbon-Nanotech Enclosure superseeds the A.C.T. Monocoque, however the complex multi layer construction of the A.C.T. Monocoque remains the industry benchmark.

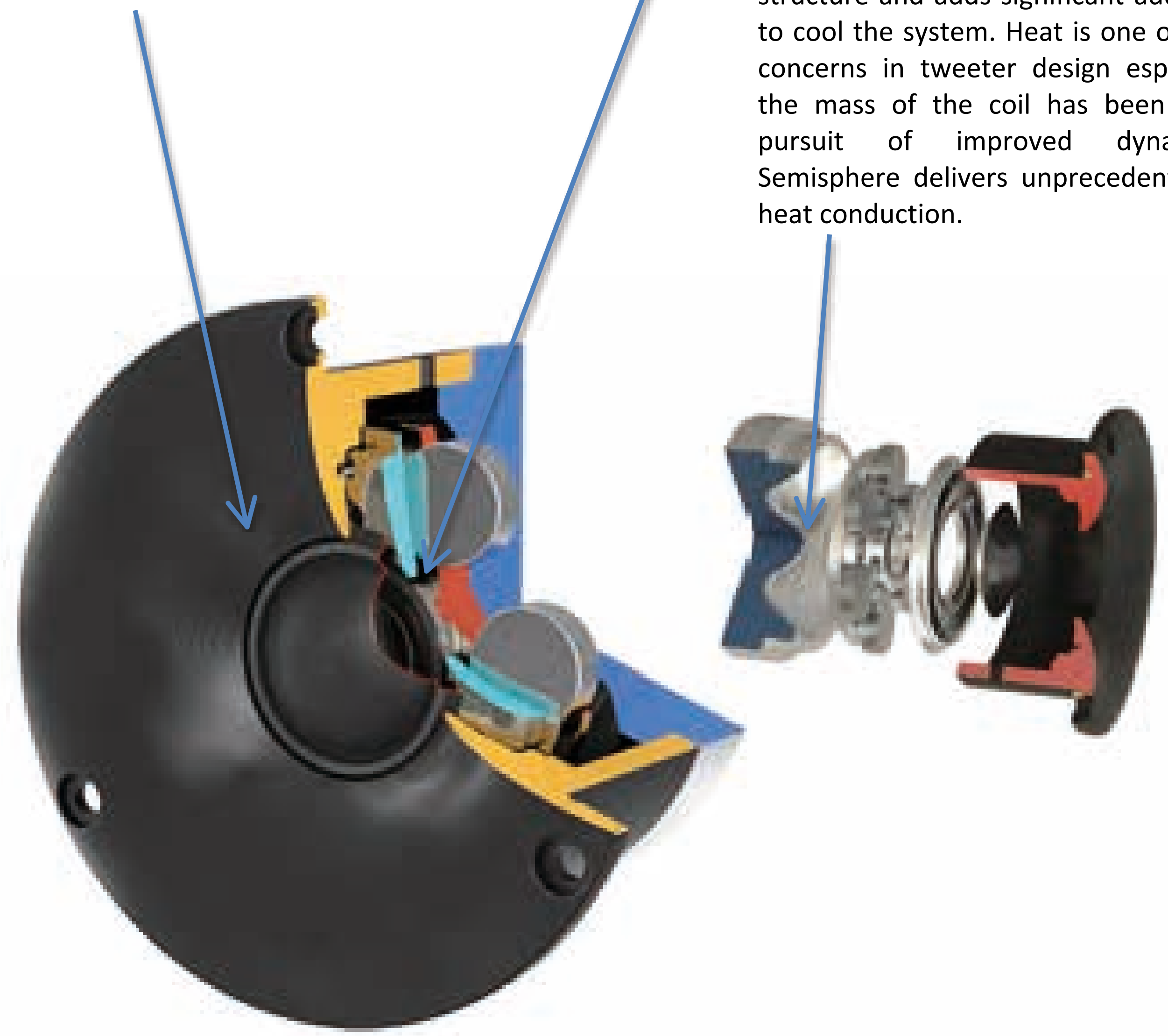
Semisphere Tweeter

The Semisphere was developed to match precisely and without compromise with the Tactic II drive unit. It functions with the simplest of crossover to ensure the lowest possible level of distortion. Like all Wilson Benesch components, every single facet is manufactured in house which is quite unique. It is this level of control that defines the component and ultimately the final product.

The huge metal face fulfills a variety of key functions. It couples energy from the dome and matches it to the air. It places the voice coil further back, to time align more accurately with the mid range drive units. It provides a huge heatsink, to dissipate heat from the powerful voice coil. It provides the ideal geometry to integrate seamlessly, with adjacent mid range drive units.

The voice coil functions in a high precision gap that has been determined after finite element analysis. Each metal component is machined in house to exacting tolerances that deliver near ideal geometry. The air behind the dome and adjacent to the coil is free to exhaust into the huge rear chamber.

Huge metal end cap ensures high integrity structure and adds significant additional mass to cool the system. Heat is one of the biggest concerns in tweeter design especially when the mass of the coil has been reduced, in pursuit of improved dynamics. The Semisphere delivers unprecedented levels of heat conduction.



Recessed Rhodium Terminus

As in the Cardinal, great care has been taken with the Endeavour terminal design to ensure the speaker cables can be concealed on the underside of huge aluminum foot.

The high purity copper alloy coated rhodium terminals deployed across the Geometry Series offer the finest conductive connection between the speaker cable and the loudspeaker. The high purity copper offers excellent conductive capacity to ensure high-speed signal propagation with minimal signal degradation. Silver rhodium plating is added to protect the copper from oxidation and corrosion. Rhodium is one of the rarest and most valuable precious metals and is commonly used to plate white gold and sterling silver jewelry to protect and provide a high quality finish.

Whilst a very simple structure, the nut and bolt remains common place in every field of engineering. It is a near perfect solution in terms of function and reliability.

Is there any need to make the connection more complex?

Wilson Benesch have tested numerous other types of terminal, including some very exotic looking designs, but in this respect we went back to basics. The most simple solution proved to the least complex, but best and most reliable in terms of ensuring an oxygen free, high pressure, high surface area connection.

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