

Accelerating Acoustic Innovation with COMSOL Multiphysics®

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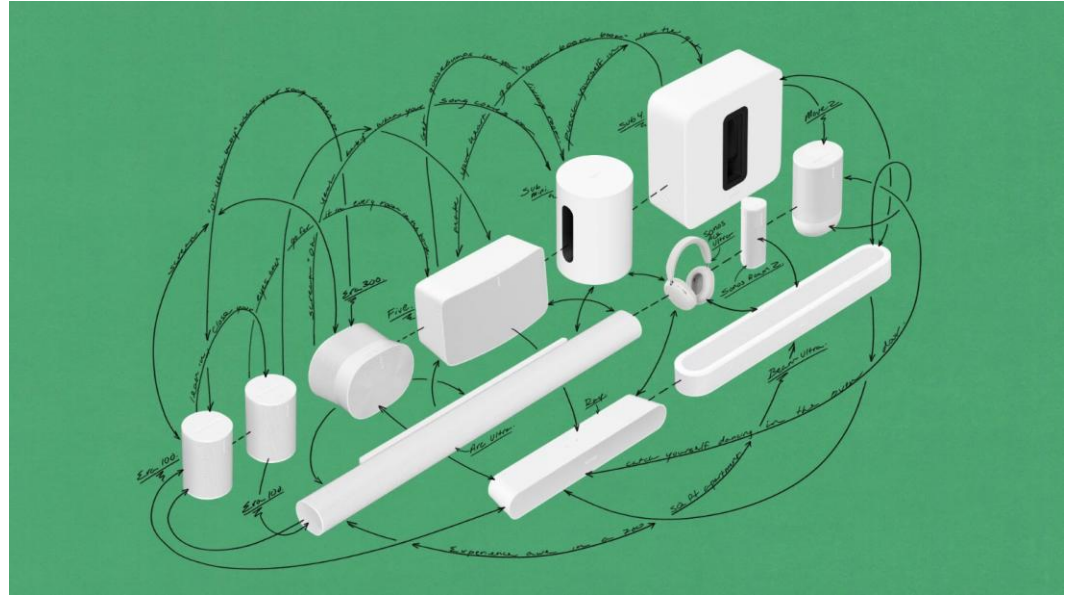
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2. What we set out to do
3. How we did it
4. What we made

Who we are

Sonos is a leading audio technology company that revolutionizes how people listen and connect to sound.

Since inventing wireless multiroom audio, we've continued innovating, creating wireless speakers, home theater systems, headphones, architectural components, and whole home audio solutions that have defined categories, pushed the boundaries of what's possible, and delighted listeners all around the world.



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Who we are

Part of Acoustic Engineering < Audio <
Hardware < Product

Located in Nieuw-Vennep, The
Netherlands



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What we set out to do

Introduce a novel transducer architecture - Sound Motion™

Loud, clean bass in compact form factor

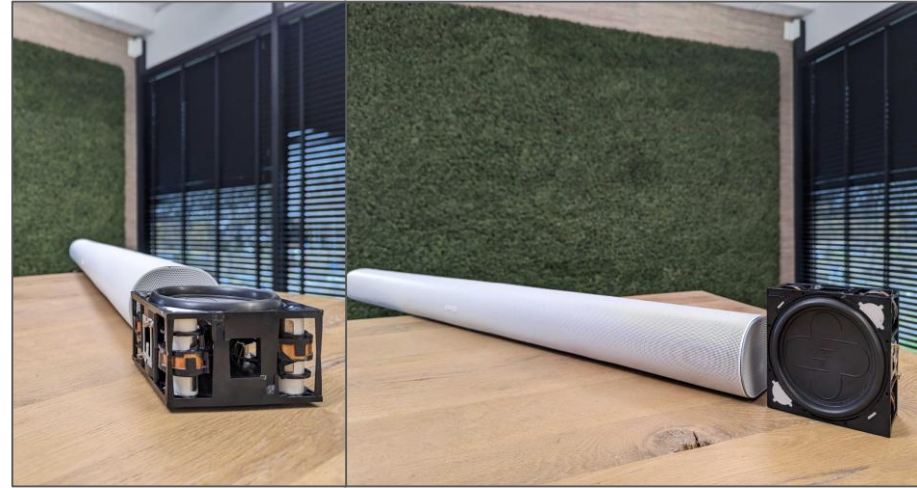


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What we set out to do

The Product Challenges:

- Form Factor Fit
- Technology Readiness



What we set out to do

The Engineering Challenges:

- Traditional fabric “spider” suspensions cannot be accommodated
- Distributed masses and driving forces create a diaphragm rigidity challenge, compromising the range of rigid-piston behaviour



How we did it

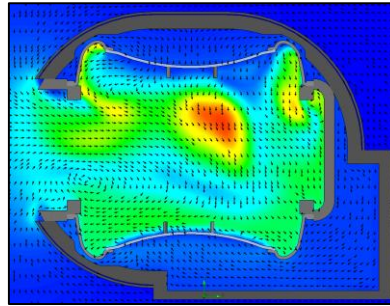
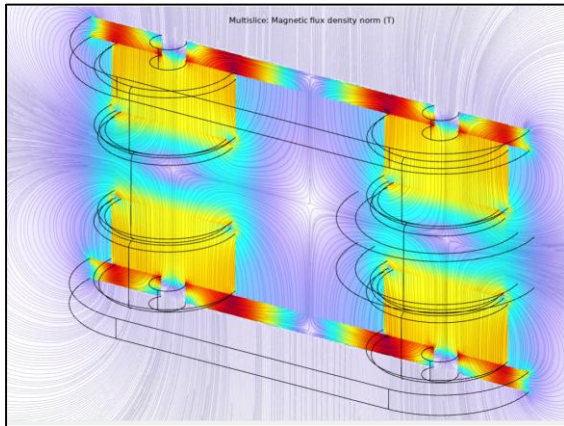
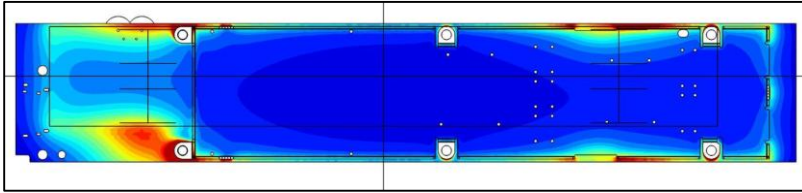
A lot of simulations and a lot of prototyping!

- 1000+ CAD Versions
- 100+ 3D Printed Prototypes
- 5 Soft Tool Prototypes
- 2 Engineering Tool Prototypes



How we did it

Every part simulated and prototyped.
As a component and in assemblies



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How we did it

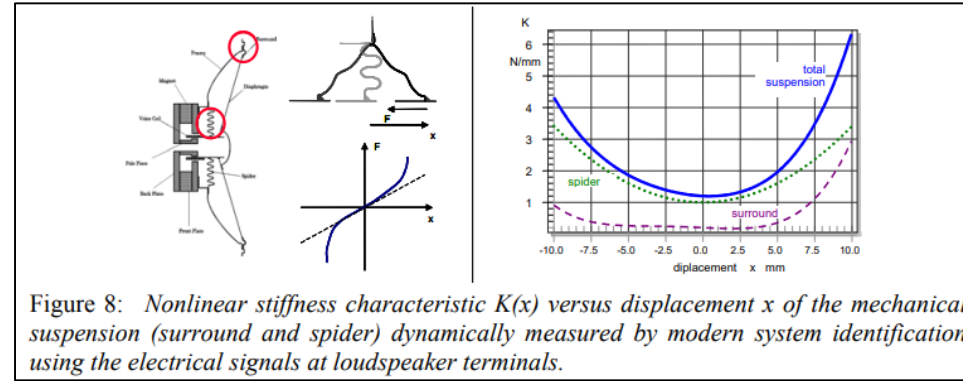
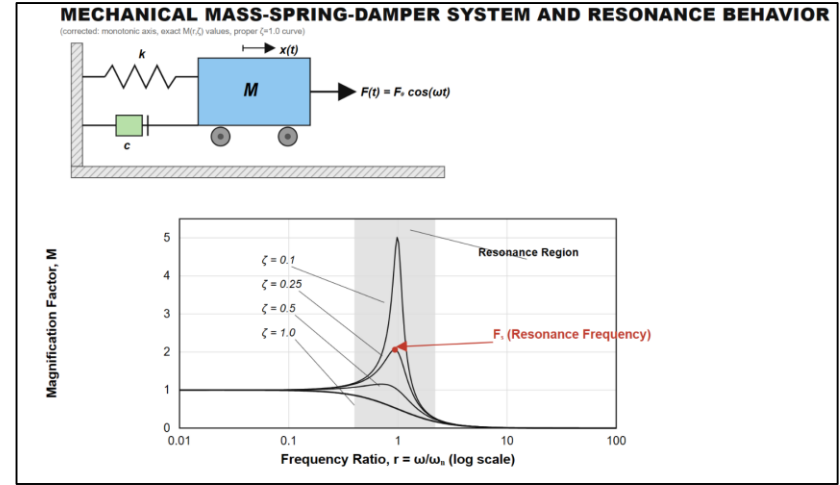
Design Objectives - Spider and Ribs

- Achieve the right spring stiffness, moving mass and consequently the target resonance frequency, with stiffness remaining linear over the full displacement range.
- Ensure natural modes fall outside the operational bandwidth, or are sufficiently damped.
- Constrain motion of the diaphragm to linear axial translation only.
- Withstand expected stress and strain at peak displacement without plastic deformation or fatigue failure over its lifetime.

How we did it

Design Objectives - Spider and Ribs

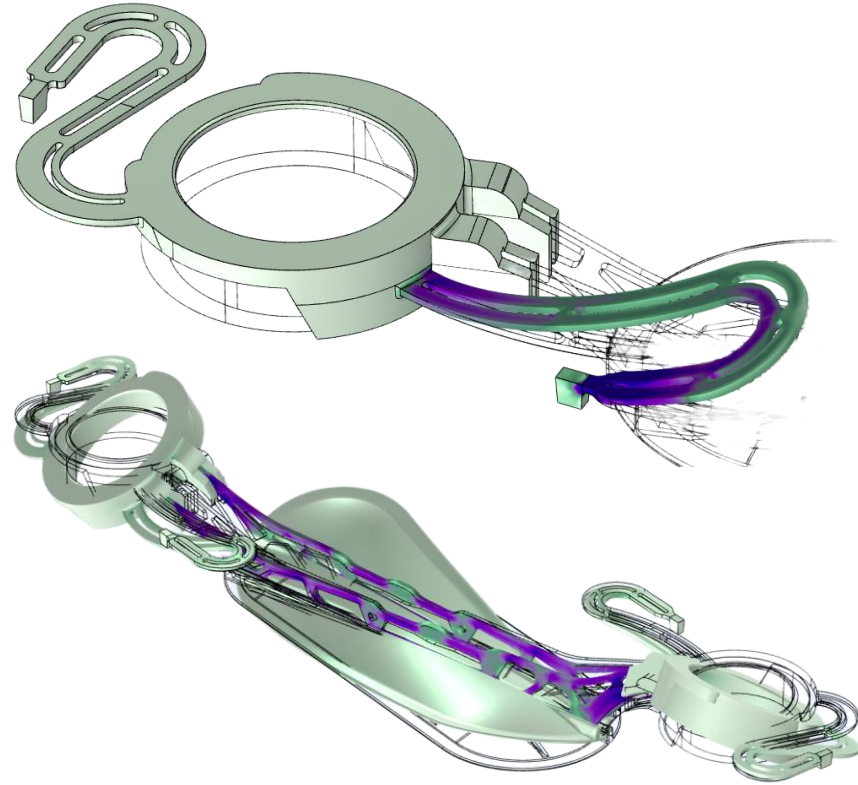
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How we did it

Design Objectives - Spider and Ribs

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How we did it

Design Objectives - Spider and Ribs

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How we did it

Design Objectives - Spider and Ribs

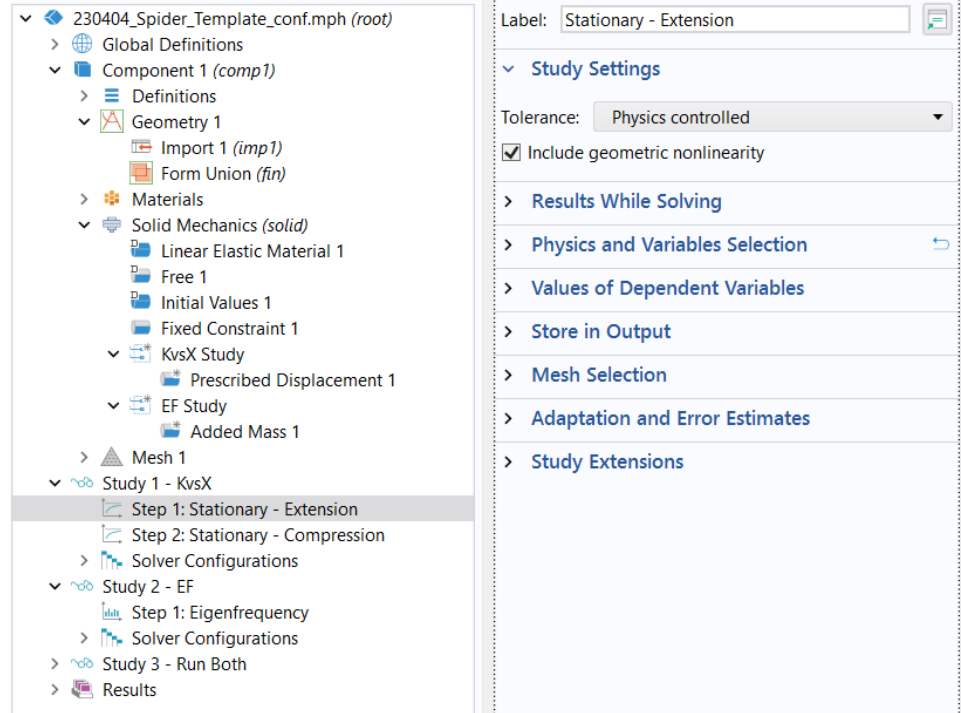
- Withstand expected stress and strain at peak displacement without plastic deformation or fatigue failure over its lifetime.



How we did it

COMSOL Details - Spider

1. Physics - Solid Mechanics
2. Study - Stationary
3. Geometry - Imported CAD
4. Boundary Conditions
 - a. Prescribed Displacement
 - b. Fixed Constraint
5. Geometric nonlinearity



How we did it

COMSOL Details - Spider

Results

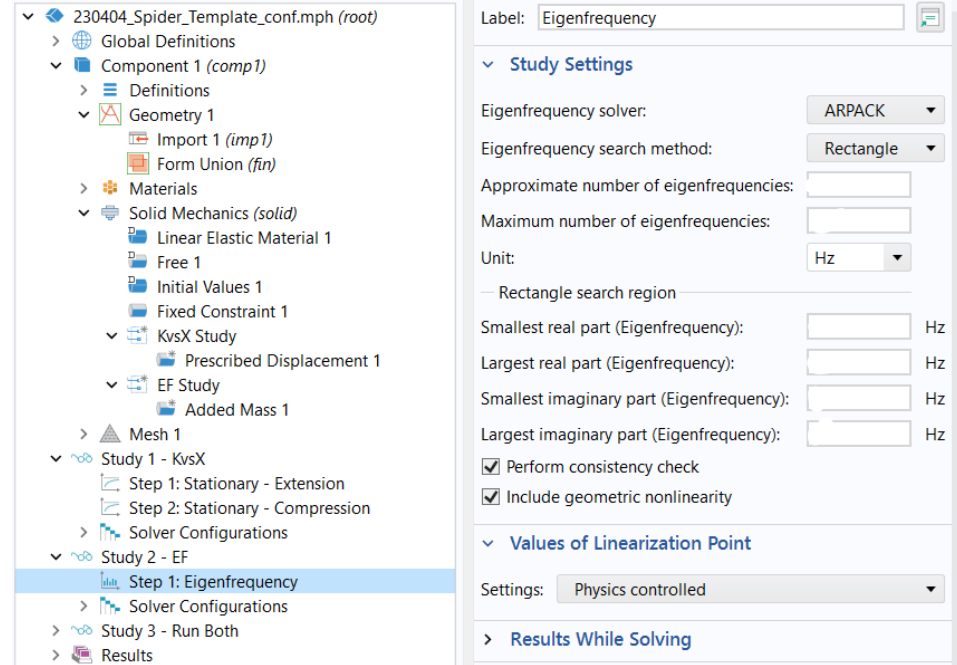
- Von Mises Stress plots
- Spring Stiffness - Integration of Reaction Forces at Fixed Boundaries



How we did it

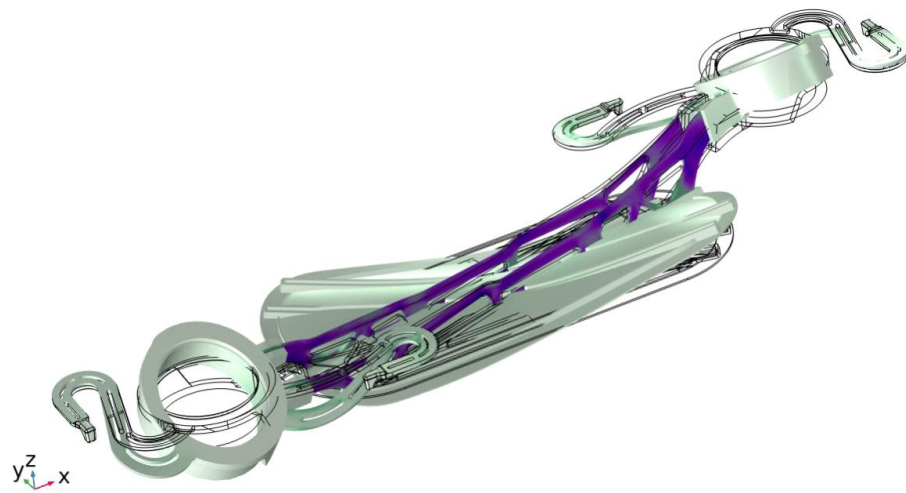
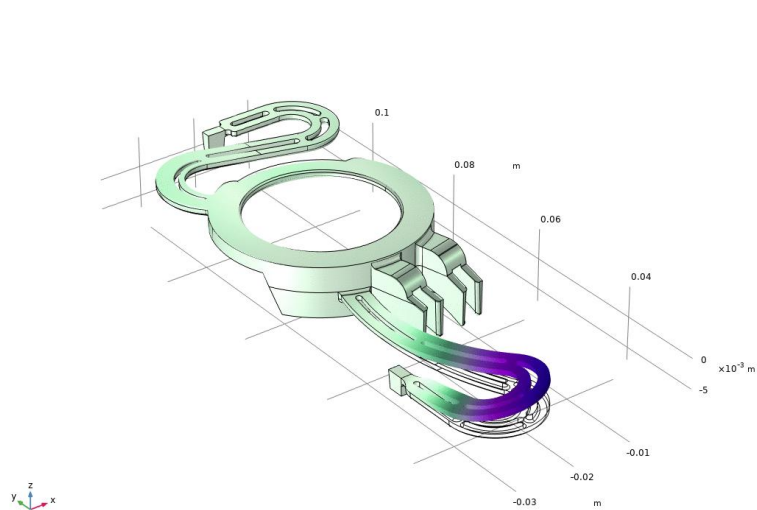
COMSOL Details - Spider

- Physics - Solid Mechanics
- Study - Eigenfrequency
- Geometry - Imported CAD
- Results
 - Mode Shape plots



How we did it

Spider



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How we did it

COMSOL Details - Ribs

1. Physics
 - a. Solid Mechanics
 - b. Topology Optimization
2. Studies
 - a. Topology Optimization
 - b. Stationary
3. Geometry - Imported DXF

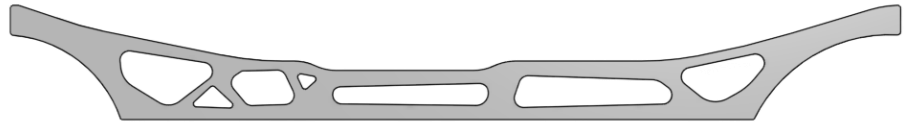
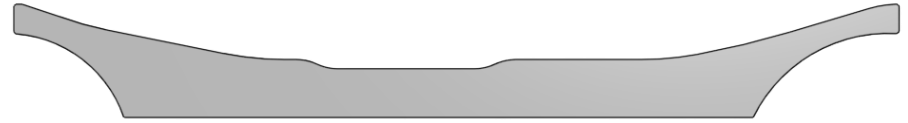
The screenshot displays the COMSOL Multiphysics interface. On the left is the 'Model Tree' for a project named 'R2.7 QB2-v60 6.4.mph (root)'. It shows a hierarchy of components: 'Global Definitions', 'Component 1 (comp1)', 'Component 2 (comp2)', and 'Optimization'. 'Component 1' contains 'Definitions', 'Geometry 1', 'Materials', 'Topology Optimization' (with 'Density Model 1 (dtopo1)'), and 'Solid Mechanics (solid)' (with 'Linear Elastic Material 1', 'Free 1', 'Initial Values 1', 'Prescribed Displacement 1', and 'Boundary Load 1'). 'Component 2' contains 'Mesh 1'. 'Optimization' contains 'Topology Optimization' and 'Step 1: Stationary'. 'Step 1: Stationary' is currently selected and highlighted in blue. On the right is the 'Study Settings' panel. It shows the 'Label' as 'Stationary'. Under 'Study Settings', 'Tolerance' is set to 'Physics controlled' and 'Include geometric nonlinearity' is unchecked. Below this are sections for 'Results While Solving', 'Physics and Variables Selection' (with a checkbox to 'Modify model configuration for study step'), 'Values of Dependent Variables', 'Store in Output', 'Mesh Selection', 'Adaptation and Error Estimates', and 'Study Extensions'. The 'Physics and Variables Selection' section contains a table with the following data:

Node	Solve for	Equation form
Component 1 (comp1)	☒	Automatic
Topology Optimization	☒	Automatic
Solid Mechanics (solid)	☒	Automatic (Station...)
Component 2 (comp2)	☒	Automatic

How we did it

Ribs

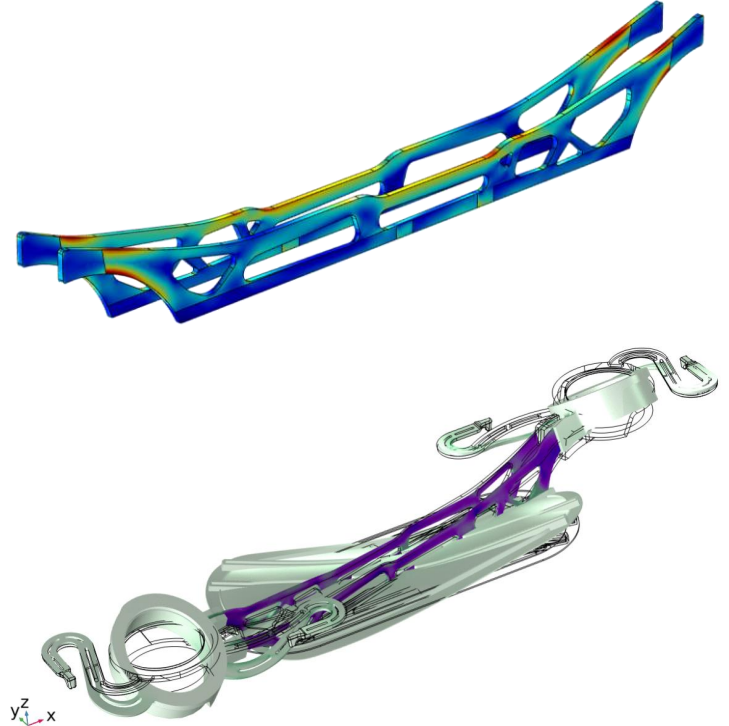
1. Boundary Conditions
 - a. Prescribed Displacement
 - b. Boundary Load
2. Results
 - a. Mesh into DXF™ → New 3D CAD → Solid Mechanics simulation for Stress and Modal Analysis



How we did it

Ribs

1. Boundary Conditions
 - a. Prescribed Displacement
 - b. Boundary Load
2. Results
 - a. Mesh into DXF → New 3D CAD
→ Solid Mechanics simulation
for Stress and Modal Analysis



How we did it

Rapid Prototyping

- Might not be the right material
- Might not survive that long
- Provides confidence in simulations
- Provides confidence in the design direction
- Saves time and cost



What we made

Arc has 8 mid-woofer transducer units.



What we made

Arc has 8 mid-woofer transducer units.

The Sound Motion transducer in Arc Ultra delivers twice the bass output of those 8 units.



What we made

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The Sound Motion transducer in Arc Ultra delivers twice the bass output of those 8 units.

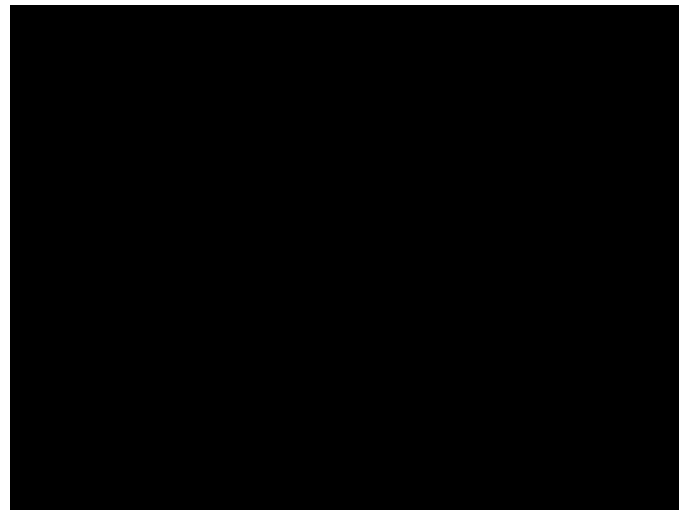
But occupies the volume of 4 such units.



What we made

Freeing space for additional mid- and high-frequency transducer units, each more specialised for their respective content.

Leading to exceptional sound experience. Not just in bass content, in spatial audio as well.



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Thank you

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Questions