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A ceiling that changes to suit the performance answers the need for acoustic flexibility, says James Rose

Raising the roof

As acoustic technology becomes more advanced, the ability of architects to control the sound quality of performance spaces becomes ever more sophisticated. The geometry of these spaces can be crafted to meet the particular acoustic needs of a concert hall, a lecture theatre a playhouse or a cinema.

But a large performance space used for all of these purposes presents a challenge: how to create a flexible acoustic design that changes as the function of the space changes?

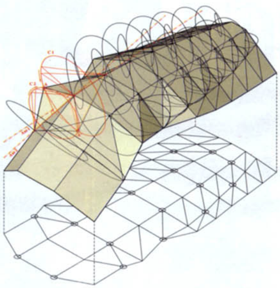
French architect David Serero believes he has found an answer. Serero, co-founder of Iterae Architecture, has been working on theatre design for the past five years and has become used to the complaints of artists dissatisfied with the acoustic performance of multi-purpose spaces. In response he has designed a multi-faceted, highly adjustable ceiling installation that allows the user to manipulate the acoustics of a room.

"It's an acoustic device which allows us to change the movement of sound in space," Serero says. "It looks a little like a carpet suspended on a number of ropes like a puppet. When you change the profile of the device, you also change the volume of the room."

He has named the installation the Acoustical Dome, a reference to the cupolas and domes of Rome's cathedrals, which fascinated Serero during a year spent at the French Academy in the city.

In 2004, Serero won the academy's Prix de Rome for his research into ancient theatres.

The prize was a year's funded research at the Villa Medici, the French Academy's headquarters, surrounded by artists from other disciplines, including a composer, a set designer, an artist, a chef and a graphic designer.



Left: A geometric calculation of the ceiling installation based on a system of tessellation. Right: The prototype ceiling installation for the Villa Medici in Rome. Computer-controlled winches roll and unroll to change the shape of the ceiling according to the type of performance.

During this time he became interested in the sophisticated geometric design of Roman domes, such as Francesco Borromini's baroque San Carlo alle Quattro Fontane.

"The old way of designing domes was to draw a lot of lines on the floor of the cathedral," he says. "A series of ropes was then put on the floor to lift the building stones exactly into place up in the dome. It explains the acoustic complexity of the domes, which reflect intricate sound patterns."

Serero has now built a prototype for the Villa Medici's 150sq m Grand Salon. The structure is composed of two layers glued together: honeycomb Alucore panels by Alcan Composites and a fibreglass woven fabric called Fabrasorb Acoustical Membrane by glass manufacturer Saint Gobain. This latter fabric is highly sound-absorbent and both layers are light: the whole structure weighs less than 200kg. The installation, comprising 65 panels, is 18m long by 9m wide. When it lies flat it leaves a gap of approximately 250mm to the walls, which grows as the panels are animated.

The dome is suspended from 12 control points on the ceiling and attached by rope pulleys to the walls. Computer-controlled winches roll and unroll to change the shape of the dome. The movement is made possible by rubber gasket joints, which act as hinges between the rigid panels.

"It is a system of tessellation," says Serero. "Where the panels are less divided, where there are only two or three, they will have much more reflective ability. You might arrange them like that above a musician to send the sound to the audience. For a voice lecture, the dome can be lowered to create faster reverberations and make the sound clearer to hear."

The architect put together a team of four to develop the project. Computer script programmer Yves Ubelman produced a digital simulation of the room's acoustics. Acoustician Christina Aureli helped the team to understand the complicated nature of acoustic fields and reverberations, while Luca Bernardi contributed expertise in model engineering.

They began by producing a computer simulation, followed by a series of experiments with larger models. The data was then fed back into the simulation.

Serero's next step will be to develop a fully motorised version. He believes that the concept could be successfully applied to both indoor and outdoor performance spaces.

Cost, however, could be an issue. The cost of the prototype was less than 10,000 (£6,800), but it would have been significantly higher if produced commercially. In this case, the manufacturers provided materials free of charge and essential computer equipment was donated by local contacts of the Villa Medici.

There were no labour costs and only the winches were motorised. A fully motorised version could cost at least £100,000 after surveying work has been completed.

Serero is now acting as a consultant for a theatre suffering acoustics problems in the Parisian suburb of Rosny-sous-Bois, where he hopes to apply his ideas.

"The management want a fixed acoustical environment," says Serero, "but I am trying to show them that they could have a wider variety of performance there with a flexible system."

● **For more information on the Acoustical Domes project, go to the Iterae website at www.iterae.com**