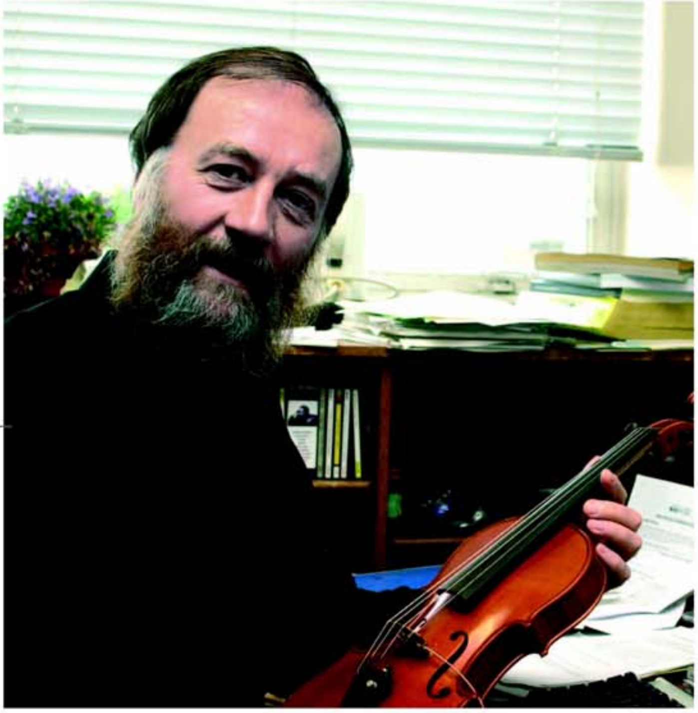
Bridging the divide

Joseph Curtin speaks to violin maker and engineer Jim Woodhouse about communicating acoustics research to today's making community



ABOVE Woodhouse in his Cambridge office

At the stately William Penn Hotel in the once sooty, now cleanly scrubbed city of Pittsburgh, Pennsylvania, members of the American Federation of Violin and Bow Makers (AFVBM) gather for the 2005 convention – three days of lectures, exhibitions, panel discussions and banquets. A distinctly British voice among the generally North American mix belongs to Jim Woodhouse, a Cambridge engineer and one of the most highly respected figures in violin acoustics. He has been flown in to talk about his recent work on the violin bridge. In its published form, the work is highly technical, but Woodhouse has the rare ability to explain complex ideas in cheerful, workshop English. He also has a genuine interest in the way that violin makers approach their work.

'I like to tag along behind them,' says Woodhouse, 'and listen to the kinds of things they talk about. It's one reason that I follow TOBI [a web-based forum on bowed instrument technology]. When violin makers ask questions like, 'What will happen if I cut a bit more wood off the f-holes here?' there's no way science can answer, at least not yet. We're still groping for the right way to frame these kinds of questions. But every so often something comes along that I think I can say something useful about.

'There is also an educational process I can help with. Makers have mental models of vibration and sound – it's part of their intuition. These models may work well enough in practice, though not always for the reasons the makers think they do, but sometimes the model is quite obviously upside down and that's where I can have a role in cutting out some of the rubbish.'

The day before his talk, Woodhouse and I find a table in a quiet corner of the richly ornamented hotel lobby. Loudspeakers hidden high among the marble arches have been playing the same violin recording for the past two days – perhaps in honour of the convention. Makers with nametags wander in and out of an adjoining Starbucks.

'What has struck me most about the craft over the past 30 years is the growth in openness among makers, the decline in secrecy,' remarks Woodhouse. 'Though there are still makers who are sceptical about science – and quite rightly so – there is now a critical mass of people who are interested in exchanging ideas and that is moving everything forward.'

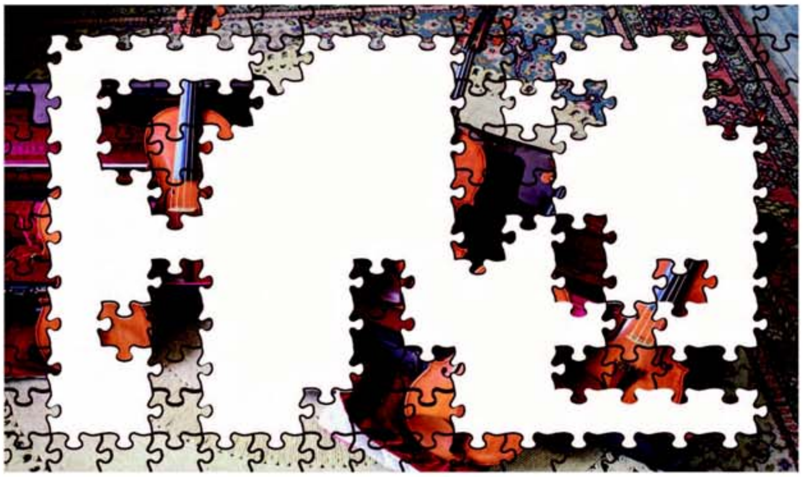
Woodhouse was brought up in the suburbs of Brighton, on the south coast of England, where he showed an early aptitude for mathematics along with an enthusiasm for making things. At 14, in the thrall of Jimi Hendrix, he built an electric guitar. 'I grew up in a do-it-yourself household,' he says. 'There was always a workshop around.' As an undergraduate at Cambridge he believed he would become an astrophysicist, but his life changed direction when he took Juliet Barker's long-running evening class in instrument making. He built a classical guitar, then a violin and he has since completed two string quartets. Woodhouse's fascination with instrument making led him to a doctoral thesis in violin acoustics under the supervision of atmospheric physicist Michael McIntyre. 'Michael is also a really fine violinist,' Woodhouse explains. 'I was told that as a young man he entered a major competition, promising himself that if he won he would give up science and become a full-time violinist. Well, he came second.'

While some researchers have devised and promoted 'scientifically based' systems for building instruments, Woodhouse carefully avoids that sort of thing. 'It's no use coming in and telling makers what to do,' he says. 'Scientific advice should come with a government health warning, "May be harmful to your instrument!" Science can be useful in sending you in the right direction, but if you follow some theory to the point where you start to think, "I don't want to do this but science says I must," then the science is probably wrong.' He offers this advice: 'Don't make your violin unusually thick or thin or bizarre in some way, just to achieve an octave relationship or some other such thing. Good violin makers make good violins. Science follows along behind. There's no way scientists are going to tell makers how, in any general sense, to do their job better.'

Woodhouse believes, however, that there are ways in which science can help. 'The wolf note is an unusual example of how a perfectly standard bit of engineering can be used to solve an instrument-making problem,' he explains. 'Wood selection is another area that we know more or less how to approach. Old violins don't lend themselves to being cut into test strips, so we have to get at the wood properties indirectly. The experiment you want to do is measure a piece of wood thoroughly, wait 300 years and then measure it again. It would be very nice to find Strad's wood store. How does 400 years of air drying and humidity cycling change a piece of spruce? Old wood gets chalky, doesn't it? It crumbles easily. My best guess as to how it differs acoustically from new wood is that the high-frequency damping is greater. This might explain why old violins seem better at suppressing the high-frequency noise that can make new ones sound harsh.'

How far has science come in understanding the violin? Woodhouse uses the image of a jigsaw puzzle. 'The edges are done, along with a few bits in the middle,' he says, 'but much of the picture is still blank. A jigsaw puzzle is a good image for how science generally proceeds. We do the edges first because they're easier, then we work our way in. The strong point of science is that it is cumulative. I am completely confident that more and more of the picture will appear. It will take generations more learning and we may never know everything there is to know about the violin, but it's the attitude that is important.'

One name which often comes up in the conversation is that of Woodhouse's late friend David Rubio: 'He had the most colourful background of any violin maker I've met and he's the only person I know who actually ran away from home to join the Gypsies.' Rubio became a flamenco guitarist and then a renowned classical guitar maker before turning his attention to the violin. In the mid-80s, Rubio approached Woodhouse and asked if he thought there was anything to John Chipura's ideas about mineral grounds (The Strad, July 1984). He also approached two other Cambridge scientists, the chemist Ralph Raphael and the materials scientist Claire Barlow. A research collaboration was born. In 1989 Barlow and Woodhouse published a two-part Strad article (March and April) that lent new credibility to the concept of mineral grounds – causing a spike in the sales of pumice, volcanic ash, mica and other such particulates.



'A JIGSAW IS A GOOD IMAGE FOR HOW SCIENCE GENERALLY PROCEEDS. WE DO THE EDGES FIRST BECAUSE THEY'RE EASIER, THEN WORK OUR WAY IN'

Rubio and Woodhouse went on to work together on a number of research projects. For one of them, Rubio built a set of six violins. Each has carefully calibrated internal differences, but their outward similarity makes it difficult for players to tell them apart by visual clues or by feel. Woodhouse has a photo of the instruments, laid out front-to-back on a straw mat, as a screensaver on his laptop. After Rubio's death from cancer in 2000, his tools and forms passed to Woodhouse's guitar making son, Martin, whom Rubio had taught.

Woodhouse's talk is scheduled for 8.30 on the final morning of the conference. When speaking, he tends to sway from side to side with enthusiasm and his delivery is as informal as his dress. He refers to a complicated looking graph as a 'wiggly line' and explains why violin makers might want to take a second look at it. 'Violins may all be different,' he says, 'but they're actually no more different, one from another, than most other manufactured objects.' He then shows a slide of the sound output of ten old Italian violins – ten wiggly lines laid on top of each other to show a range of individual differences and a common overall shape. ▸

Figure 1 The vibration mode of a violin bridge associated with the 'bridge hill'

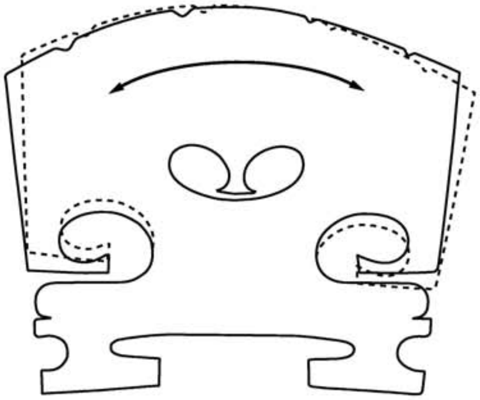


Photo of Woodhouse: Keri Wallace; all other images: Jim Woodhouse

A wave of laughter ripples across the room as the audience digests the next slide, which shows roughly the same range of differences in the acoustical behaviour of 98 cars off the same production line and then of 41 nominally identical beer cans. 'The thing about violins is that people care about the differences,' Woodhouse says. 'With most noise and vibration problems, the client isn't much interested in the fine details of the acoustical behaviour; they just want to know where to slap a little damping to make the noise go away. The violin is almost unique in that the fine details matter – to an almost ridiculous level – making it a good challenge for the scientist.'

An acoustical feature that fine violins seem to share, Woodhouse explains, is a broad peak in sound output between about 2,000Hz and 4,000Hz, around the region of the ear's greatest sensitivity. Swedish researcher Erik Jansson called this peak the 'bridge hill', on the assumption that it was created by a resonance of the bridge itself (see figure 1). Jansson showed that by tuning the frequency of this resonance, the violin maker can to some extent control the instrument's treble response and thus its brilliance and projection. Further research indicated that the characteristics of the bridge hill are determined not just by the frequency of the bridge resonance but also by the mass of the bridge, the distance between its feet and the 'springiness' of the top upon which it sits.

Woodhouse has applied some of the latest tools from vibration theory to create a mathematical model of the bridge on a violin, in an attempt to determine the contribution of each of these parameters. This model exists only on a computer, but when the instrument was set into virtual vibration, a bridge hill did indeed appear in its response curve. Woodhouse then independently varied each parameter, plotting graphs to show how each change affected the bridge hill (see figures 2–6).

Never one to sail away on a theoretical model, Woodhouse asked Cambridge violin maker ▸

Figure 2 the frequency response of a simplified violin, as modelled on a computer. The skeleton curve (dashed line) shows the bump of the bridge hill

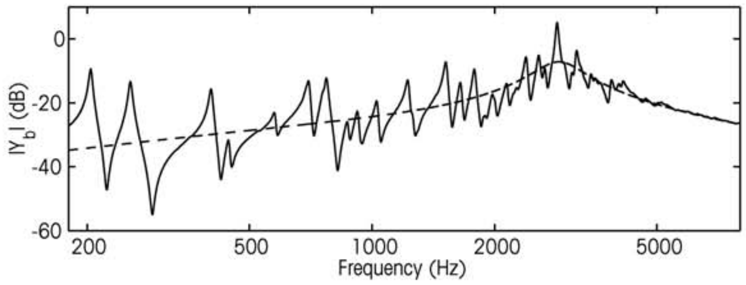


Figure 3 The skeleton curve of the bridge hill as the bridge thickness is reduced. The dashed line represents the thinnest bridge

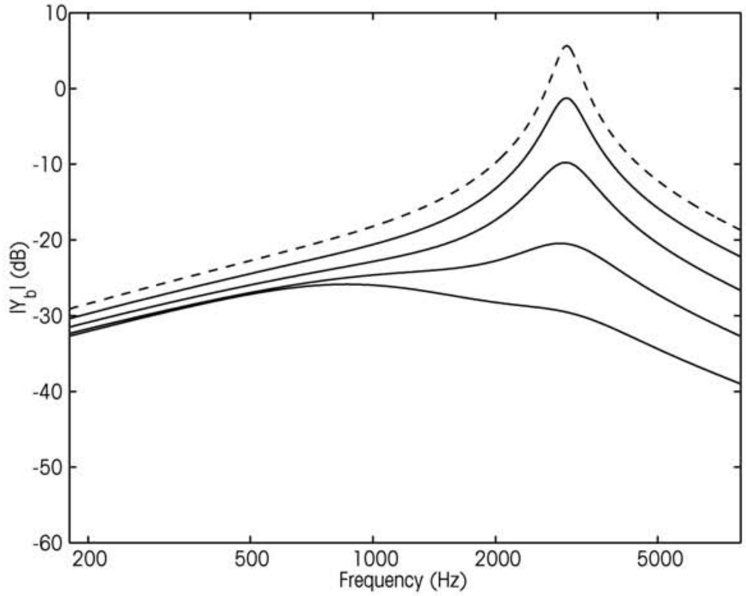


Figure 4 The skeleton curve of the bridge hill as the bridge mass is increased – by adding a mute, for example. The dashed line represents the lightest bridge

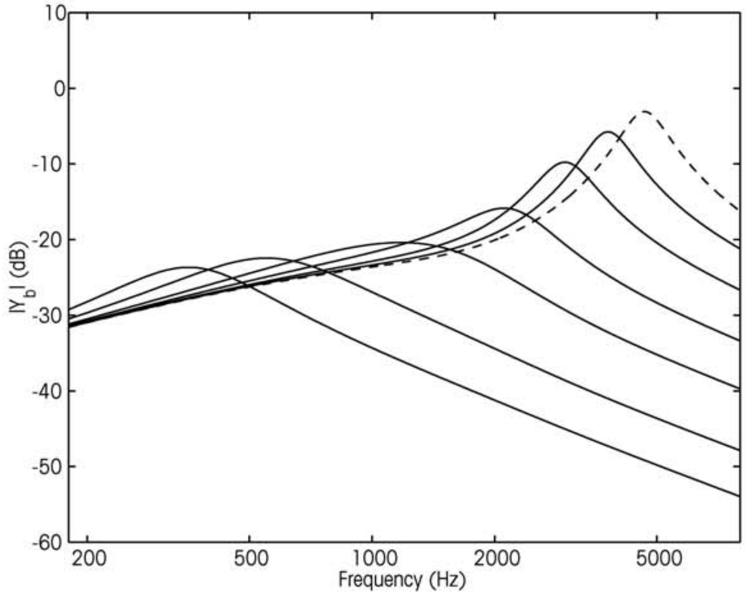


Figure 5 the skeleton curve of the bridge hill changing as the distance between the bridge feet is varied. The dashed curve has a spacing of 5mm, then 10mm, 20mm, 30mm and 40mm

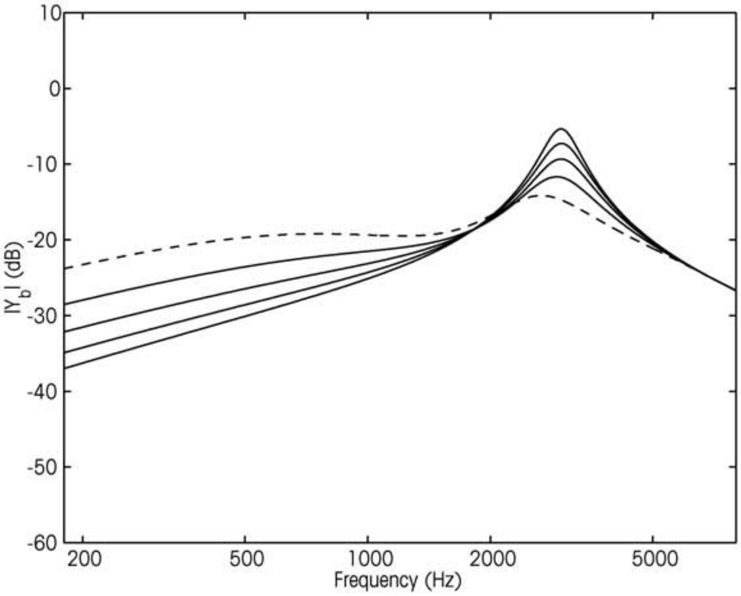
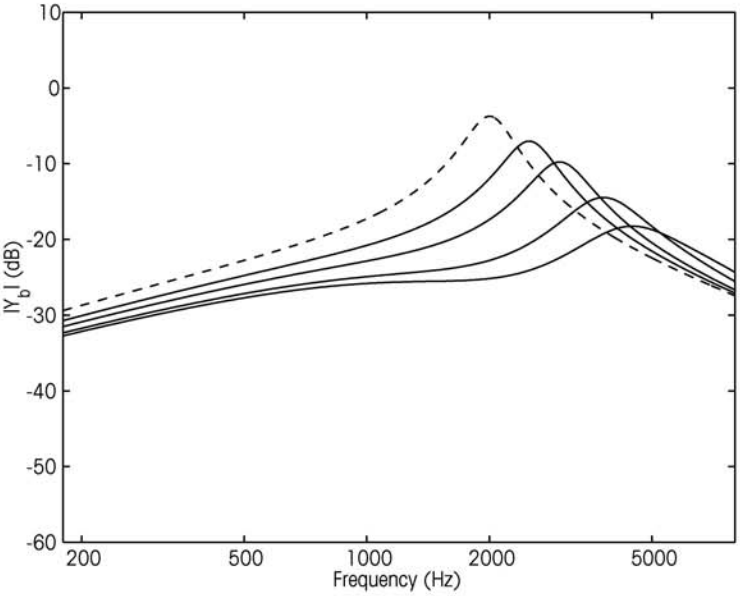
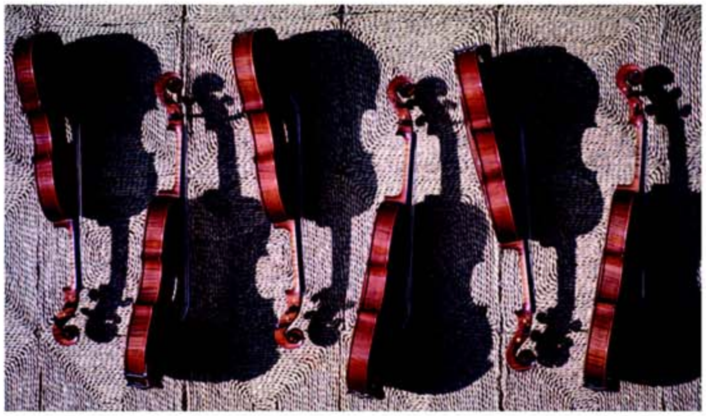


Figure 6 the skeleton curve of the bridge hill as the top plate is thinned near the bridge. The dashed line represents the thinnest plate





RIGHT the six violins made by David Rubio for a joint project with Woodhouse. They have carefully calibrated internal differences, but are outwardly identical

Jonathan Woolston to fit three distinctly different bridges on to one of the Rubio violins, which was then given to players for evaluation. This preliminary experiment nicely confirmed his predictions. He has brought the three bridges with him to Pittsburgh and holds them up for the audience, explaining that they are DeJacques models with adjustable feet, so makers with an interest are welcome to try them on their violins.

Every maker knows that tiny variations in the cut and design of a bridge can make large differences to the sound of an instrument – differences that can make or break a sale. Woodhouse's results provide a kind of map for violin makers wishing to systematise their approach to bridge cutting. If his predictions bear out, makers have a surprisingly large and perhaps under-exploited degree of control over one of the violin's most crucial acoustical features, the bridge hill. This is some of the best news to come out of the research community in years.

THE RESULTS PROVIDE A MAP FOR MAKERS WISHING TO IMPROVE THEIR BRIDGE-CUTTING

The AFBVM meeting finishes that evening with a banquet. Organisers and guest speakers are publicly toasted and warmly applauded. As the waiters clear away the last coffee cups and wine glasses, an end-of-convention nostalgia fills the room. Woodhouse tells me about his next violin project – a virtual instrument to be built with digital filter technology. Tonal changes that might take weeks to implement on a real violin will be achieved in a few keystrokes. The instrument will be played by recorded string signals from real players and heard via loudspeakers. Panels of listeners will fill out questionnaires for later analysis. If all goes well, another piece will fall into place on the jigsaw puzzle. ■