MACH ACOUSTICS

The Future of Windows

www.machacoustics.com

TOWARDS NATURAL VENTILATION

To create more sustainable buildings, mechanical ventilation must give way to naturally ventilated designs which can reduce a building's energy consumption by half. But letting in fresh air also allows in noise, so acoustics and ventilation often compromise one another. In noisy, urban locations we resort to using clumsy acoustic attenuators or keeping windows shut to avoid noise break-in.

Extensive research, testing and modelling by MACH Acoustics shows that better functioning, well-engineered window designs can mitigate against noise while allowing natural ventilation. Here we outline the scope of our work and how windows of the future might look.

ACOUSTICS OF OPEN WINDOWS - WHAT WE KNOW

Current understanding of the acoustic performance of open windows is limited.

Present guidance (table on the right) indicates that the sound reduction of a facade containing open windows is between 10 and 15 dB.

However, this is very simplistic, with no information on how the performance is affected by the window type, the size of the opening, the number of windows or the location of the sound source relative to the window. It is not clear what constitutes a 10 dB window, or what is a 15 dB window.

Much of this data is also nearly 20 years old, where the capabilities of testing and modelling the performance of open windows are significantly better in the modern day.

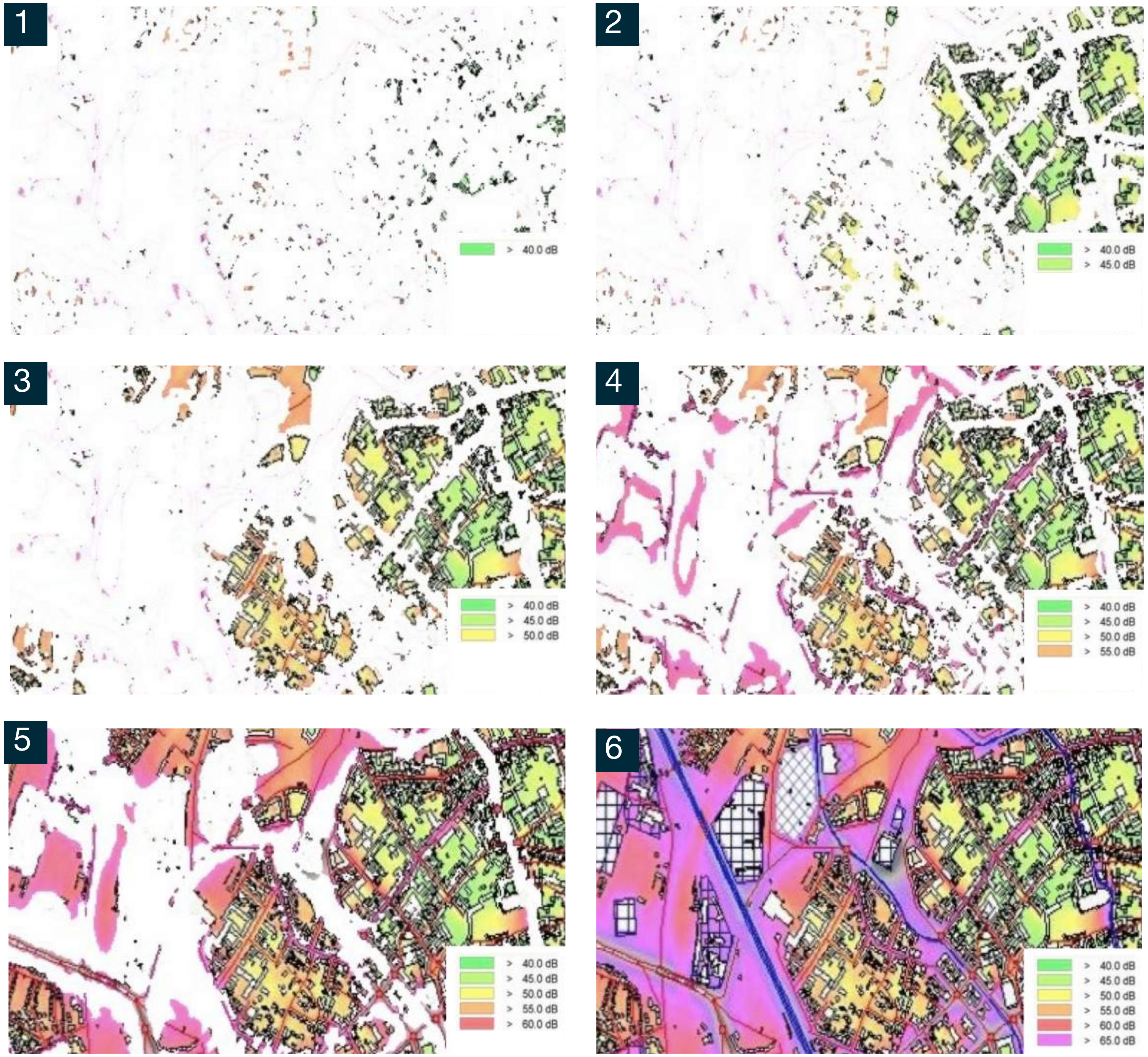
Document	Sound insulation
BB93	10 - 15dB Rw
BS8233:1999	10dB or 15dB
EN 12354-3:1999	Rw of 10 - 15dB
WHO (1999)	10dB - 15dBA
PPG 24 (1994)	10 - 15dB(A)
BRE Digest 338 (1988)	10 - 15dB
Nelson – Transportation noise (1987)	5 - 15dB
DoE Design Bulletin 2	10 - 15dB(A)

DOES 5 dB MATTER?

The noise maps show a typical urban area, the coloured parts show which buildings could be naturally ventilated (based on all buildings having the same noise requirements).

The assumed sound reduction of an open window increases in 5dB intervals from 5dBA (1) to 30dBA (6).

It is clear that a 5dB variation is significant, therefore by using simplistic information of 10-15dB for an open windows performance, we could be missing out on naturally ventilating a number of properties, even with only a 5dB increase in performance.

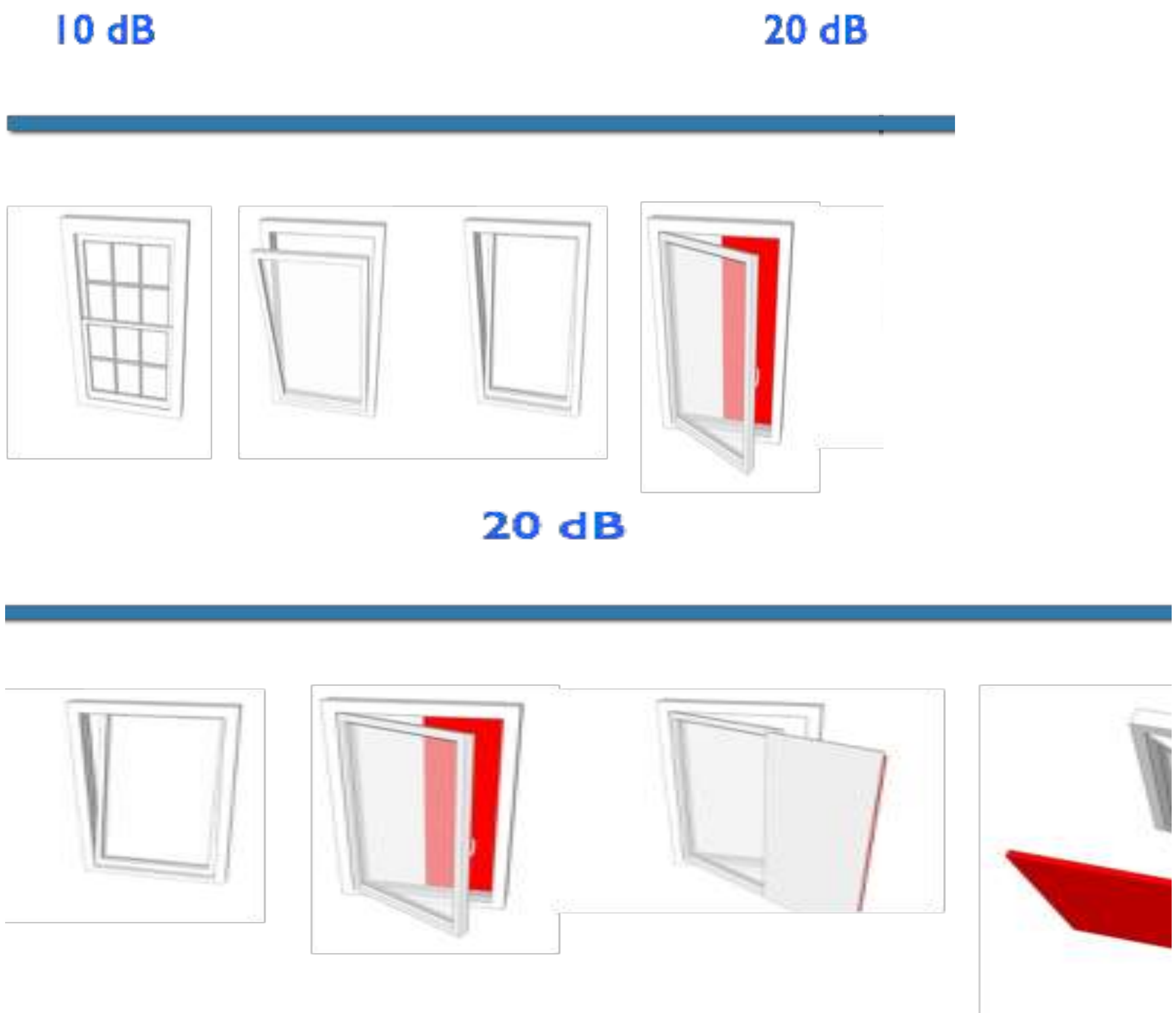


NAPIER UNIVERSITY TESTS

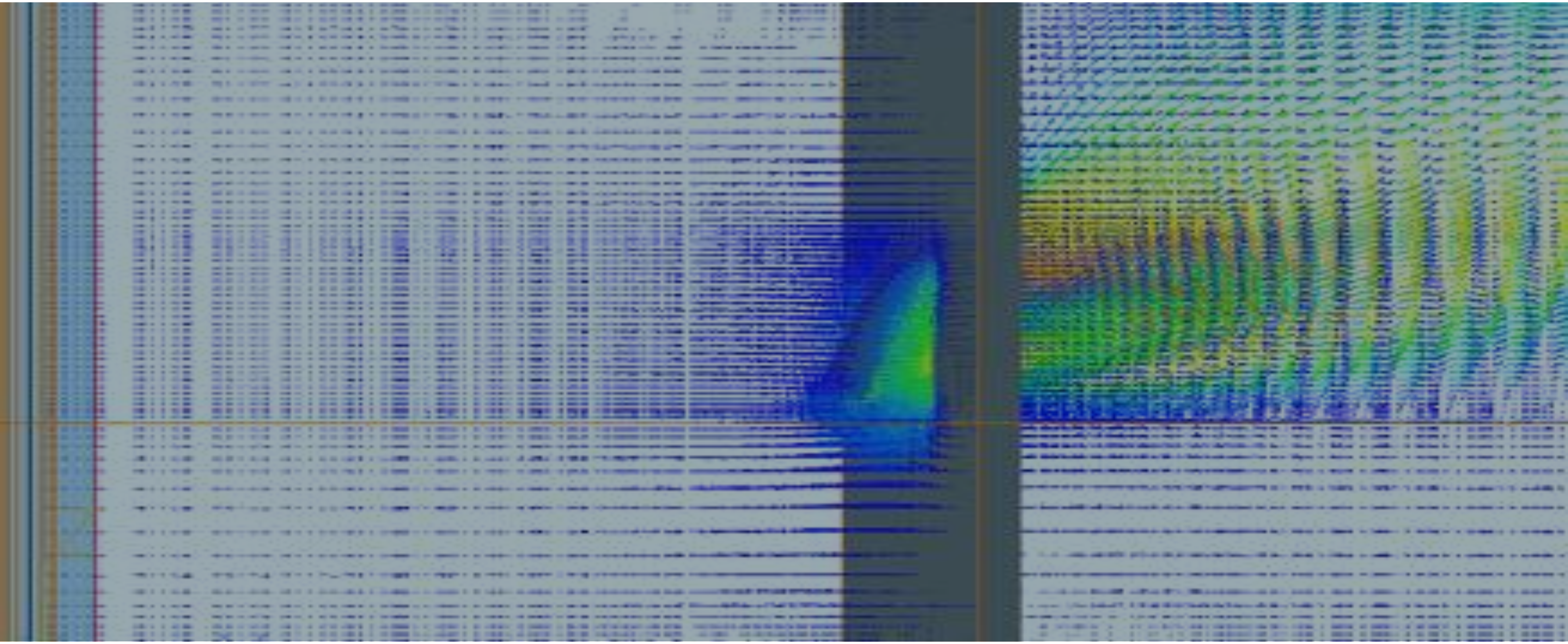
Edinburgh Napier University conducted acoustic tests to 14 different types of open window. MACH Acoustics' analysis of these findings show it is already possible to achieve greater sound reduction than 15 dB with an open window.

For choosing the correct window type such that the glazing acts as a noise barrier, shadowing the opening from the sound source, can achieve up to 23dB, opposed to 12dB for a simple sash window, with the same open area of 0.2m2. This is a clear indication that simply taking a 15dB reduction may prohibit natural ventilation in areas where it would work.

As part of our research, MACH have looked at ways of increasing the performance even further above 23 dB, using internal/external baffles to provide additional screening.



MACH ACOUSTICS



Modelling & Test Facilities

MODELLING & TESTING TECHNIQUES

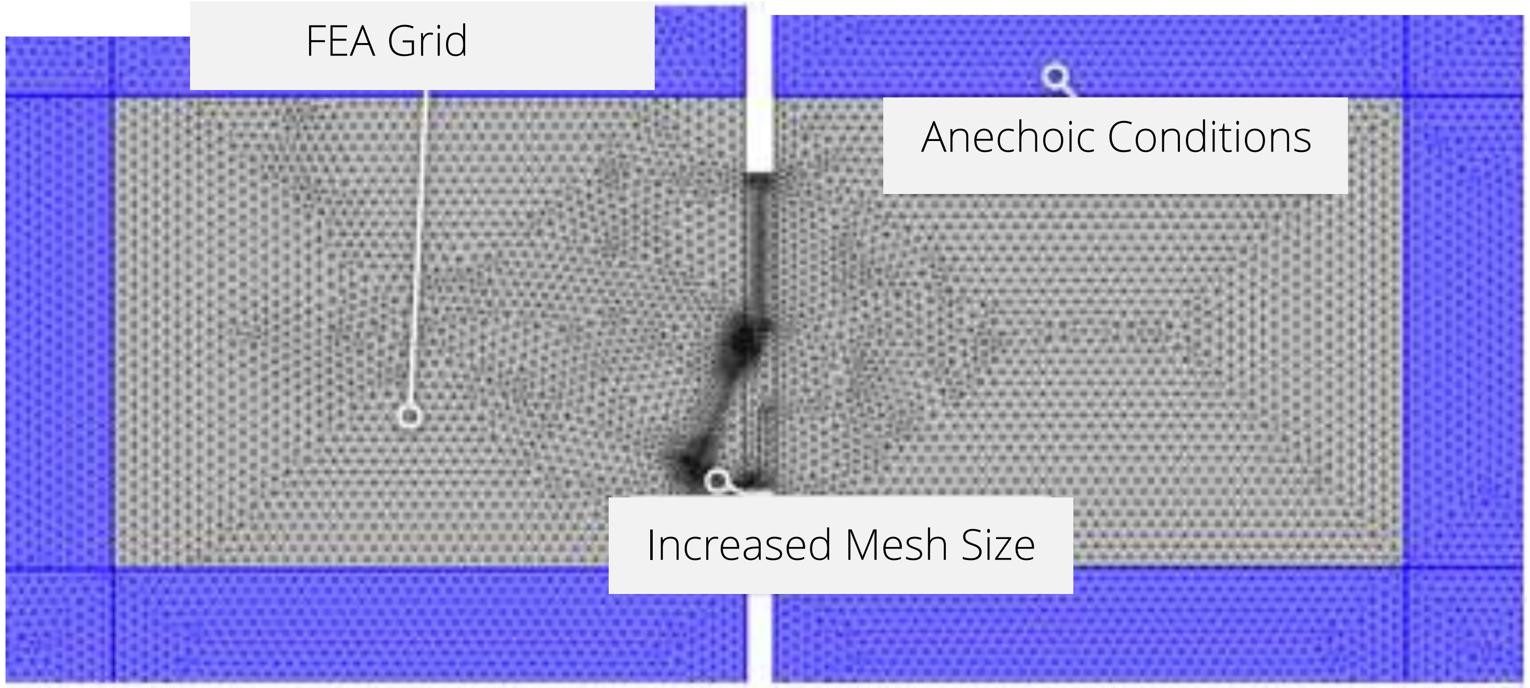
Various modelling techniques have been used or developed by MACH Acoustics to test windows:

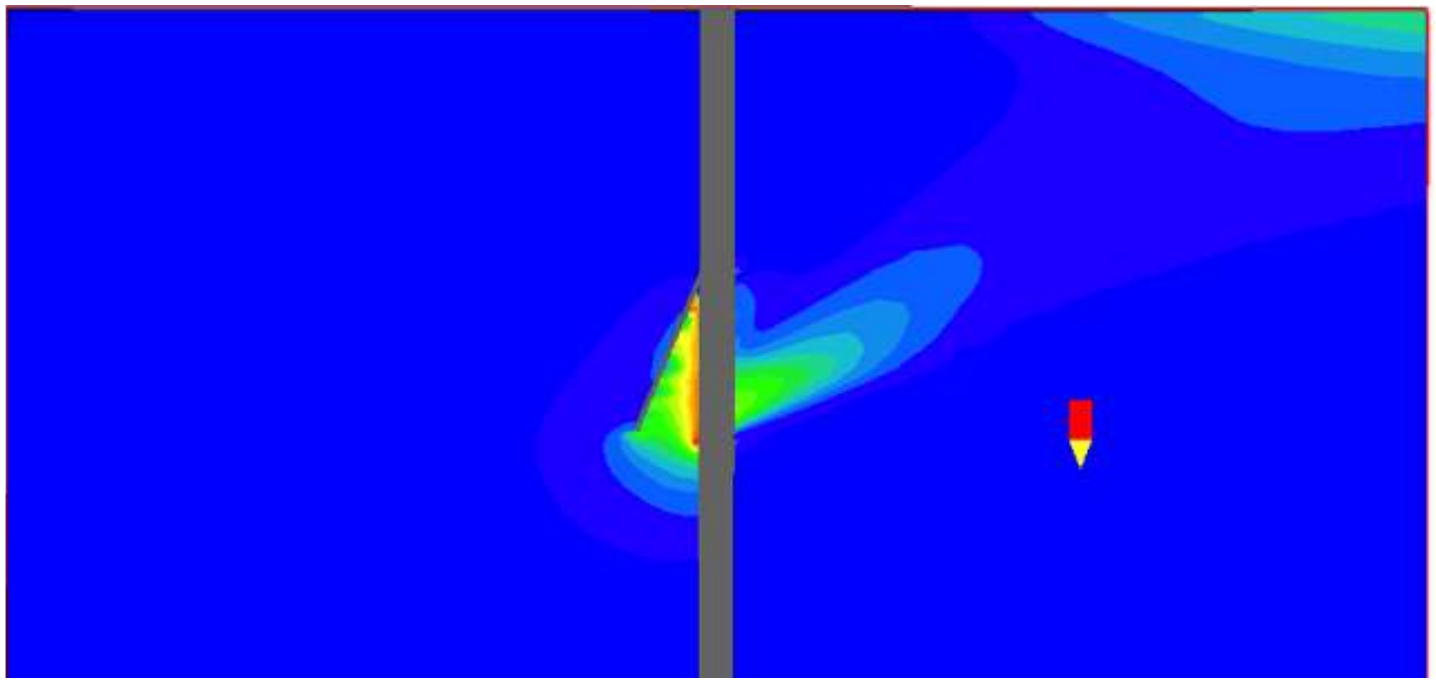
Finite Element Analysis (FEA) determines the exact frequency performance of different openings.

Finite Difference Time Domain (FDTD) modelling illustrates and presents the passage of sound through open windows as an intuitive animation.

Computational Fluid Dynamics (CFD) tests airflow through different window types.

The University of Bath's building research facilities offer acoustic and air permeability testing of windows and air vents.





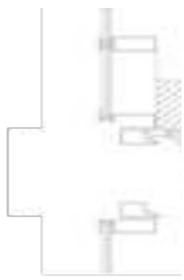
FEA MODELLING

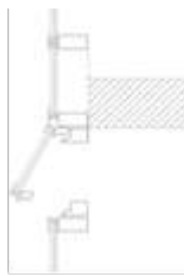
FEA modelling places a mesh over the test subject. Here the images show the effect of sound angle on different window types.

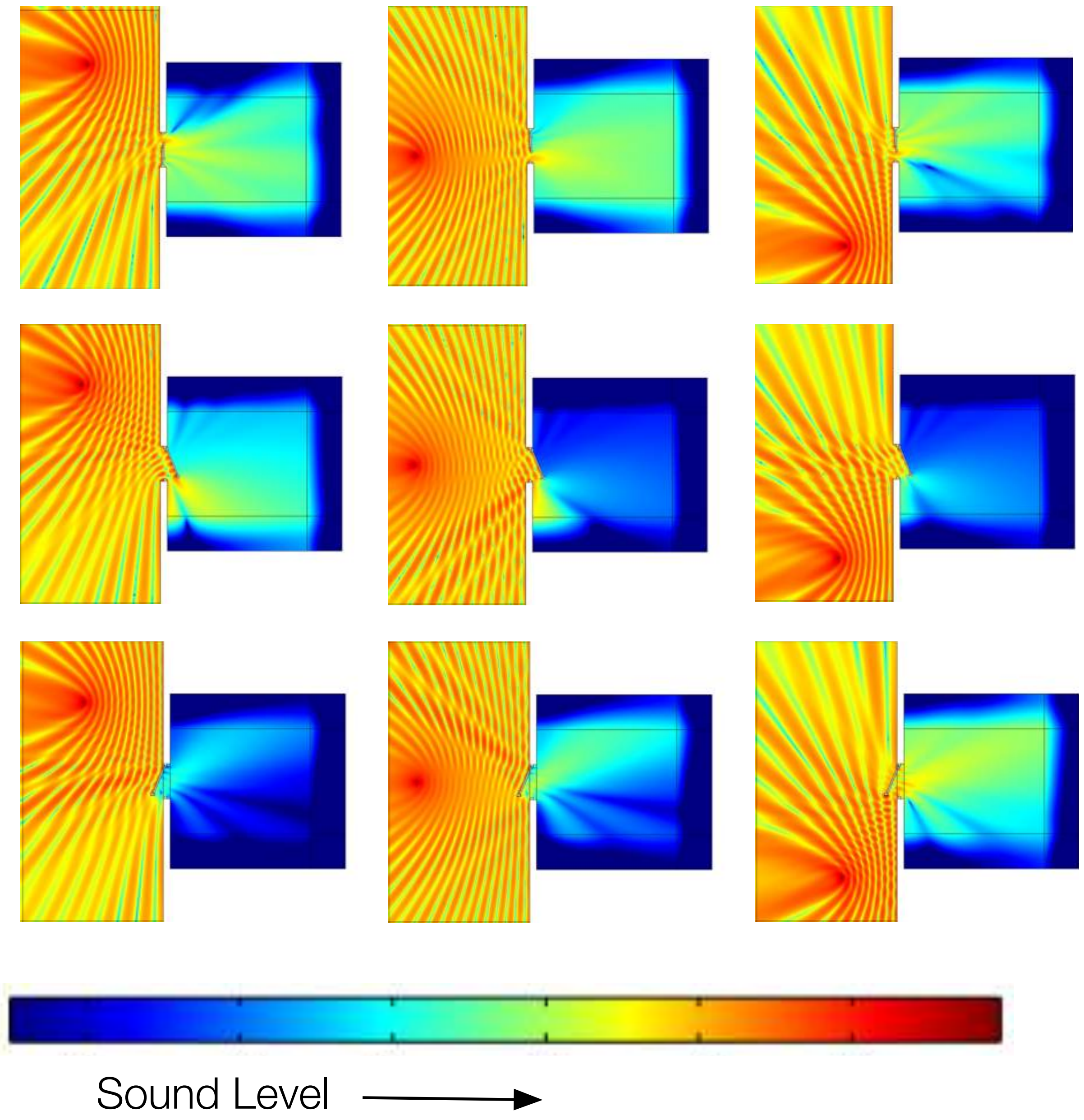
We then use a series of differential equations to determine the acoustic frequency.

The challenge with FEA and acoustic testing is that you cannot see how the sound passes through a window, or how it bends around an acoustic baffle.

The images will show you the end result, but not how the sound got there.







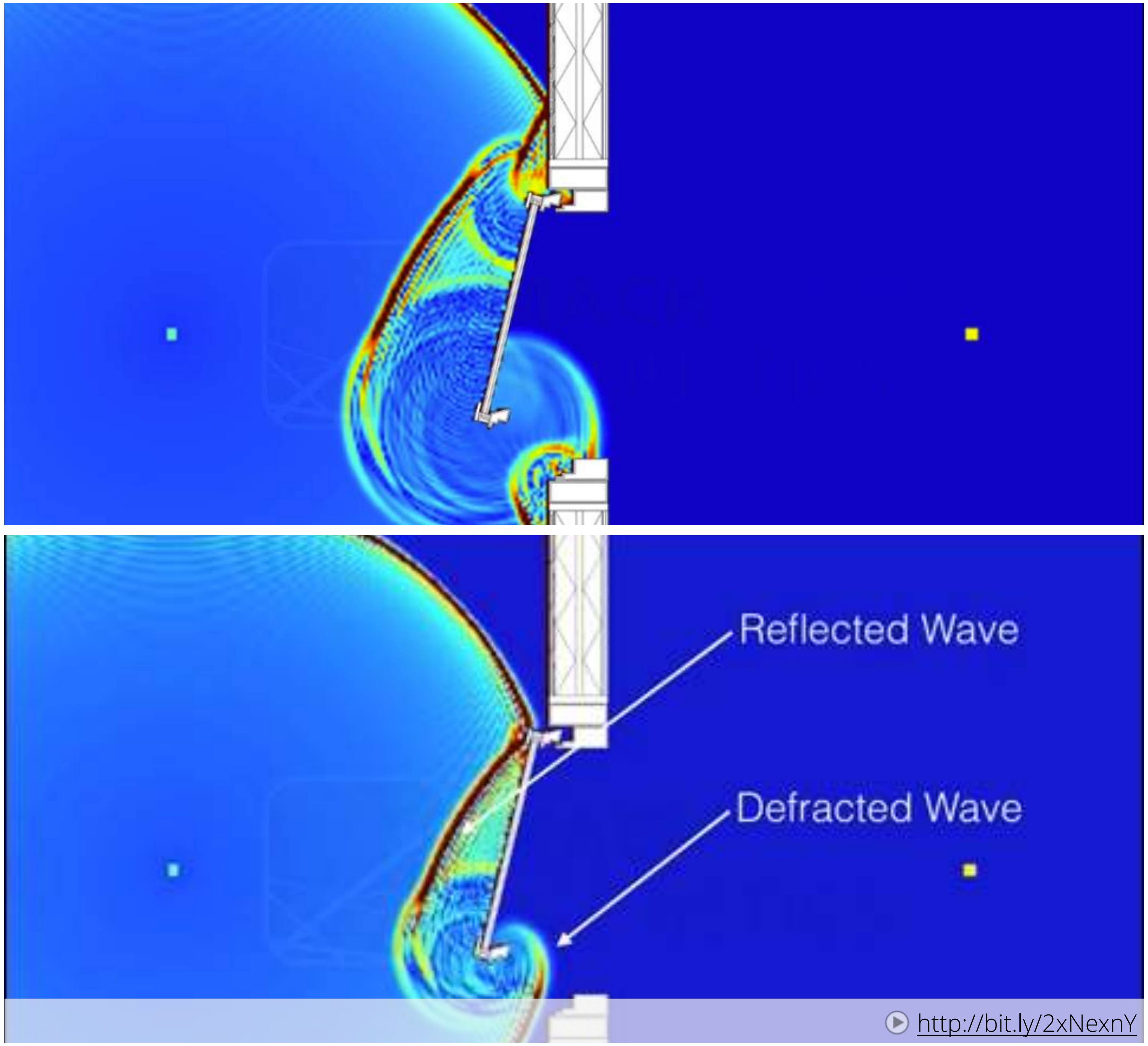
VISUALISING SOUND

In conjunction with Southampton University, MACH Acoustics has developed in-house software to visualise sound using FDTD simulations.

Unlike FEA which produces a snapshot of the end result, FDTD can be animated over time to show how the sound reached this endpoint.

The video link opposite shows the propagation of sound through an open top hung window.

With this visualization, a designer can both see and understand how the vented facade will perform and why this occurs. It is easy to see the positive and negative parts of the design, to mitigate the latter.

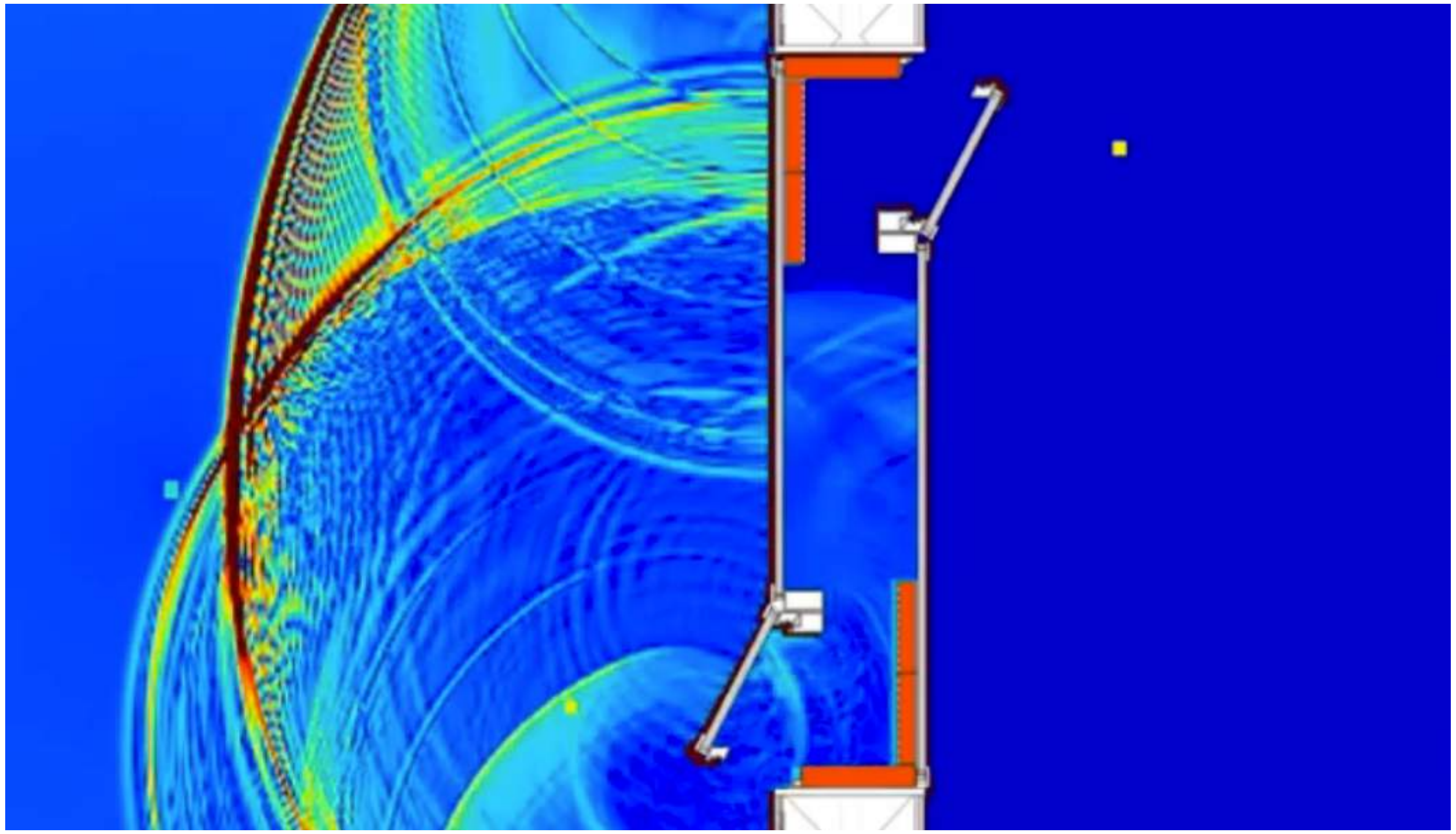


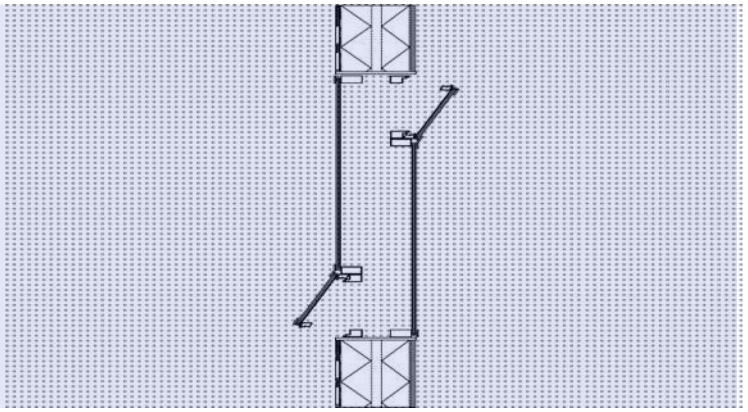
FINITE-DIFFERENCE TIME-DOMAIN

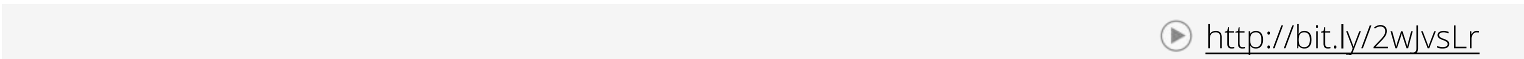
Here FDTD was used to model the acoustics of a casement window.

In this case, the grid is square in shape. The nodes at each of the points where the grid meets the model are fixed solid.

Alternatively, nodes can be made semi flexible such to represent acoustic absorption. The grid is then excited at a fixed point, resulting in a sound wave propagating across the grid, which in turn allows MACH to visualize the movement of sound.







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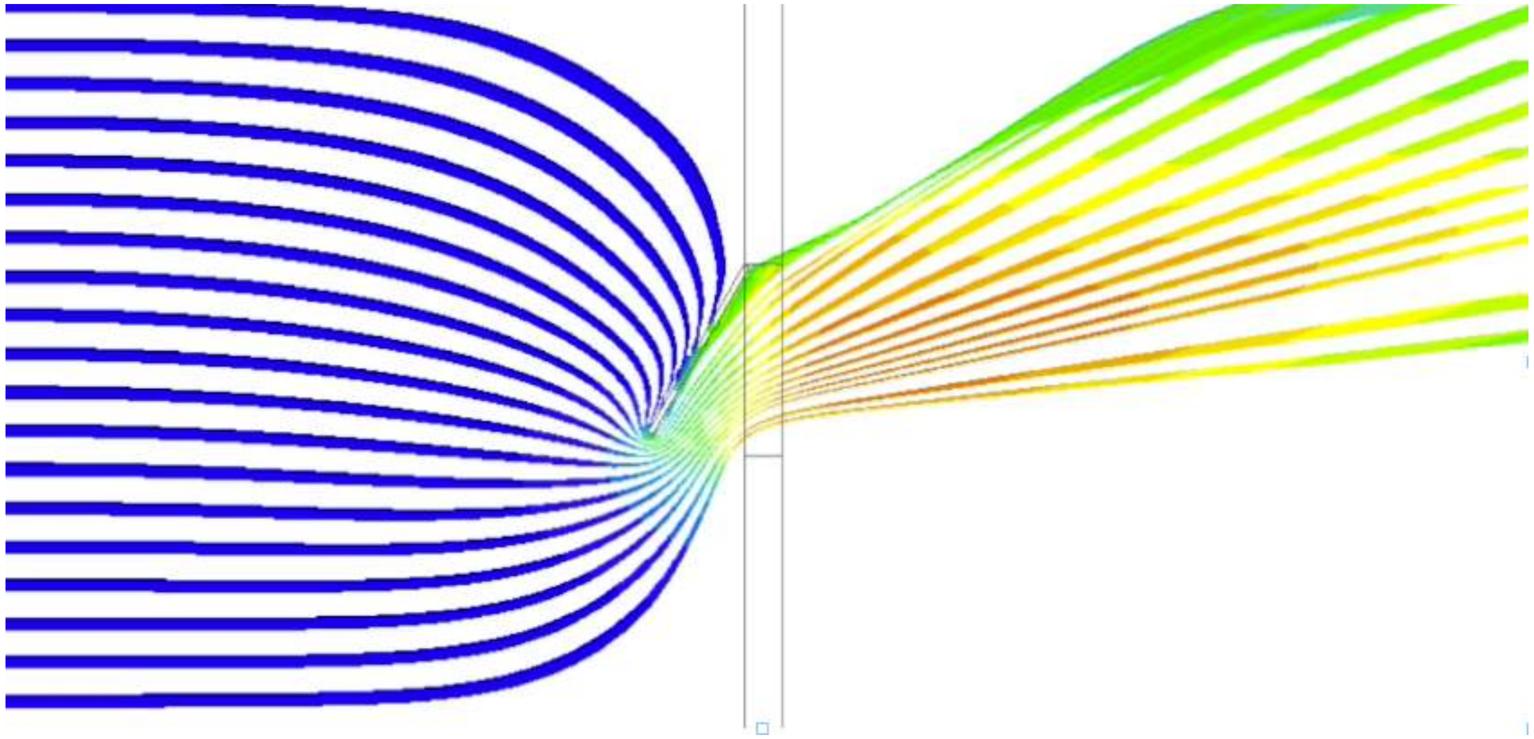
COMPUTATIONAL FLUID DYNAMICS

There is no point improving the acoustic performance of an open window if it restricts the airflow, therefore we take a holistic approach to facade design.

MACH Acoustics utilizes the test facilities at the University of Bath to measure the on site pressure drop/ discharge coefficient of windows.

In conjunction with our in house modeling software, this allows for detailed CFD assessments to be undertaken for different window types.



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How Can We Improve Window Design?

RESEARCH FINDINGS

From the early days of MACH Acoustics, we have attempted to establish the performance of windows, as well as investigating methods of enhancing the performance of vented facades.

Our analysis shows that in future using more accurate acoustics modelling and testing, a further 20% to 40% of new buildings could be naturally ventilated in noisy locations.

Our analysis of Edinburgh Napier University's research and MACH Acoustics' own field research found that:

- Angle of sound source: The size of a window's opening had less impact on noise than the angle of the noise source. Angled facades can offer even better noise mitigation and temperature control by shading a building from noise and sunshine, where needed
- Window baffles can significantly improve acoustic performance and can reduce noise ingress depending on their size, angle and location relative to the window
- Field test results were more accurate than lab tests, showing 5dB better acoustic insulation for certain windows

EXTENDED WINDOW FRAME

One of the key factors affecting the sound reduction of an open window is its ability to screen sound, i.e. the harder it is to see the sound source through the opening of the window, ignoring that is can be seen visually through the glazing, the better its acoustic performance.

Hence by simply extending the frame of the window, as shown, the sound reduction of a simple window can be enhanced.

BAFFLED FACADES

An alternative way of enhancing the performance of an open window, is to place a baffle over its opening.

MACH Acoustics' analytical tools and laboratory measurement facility can be used to determine the size and position of the baffle so as to provide the required acoustic performance from an open window.

A baffle doesn't necessarily need to be a specific acoustic product, inherent design features such as ballustrades and balconies can provide a positive acoustic effect.

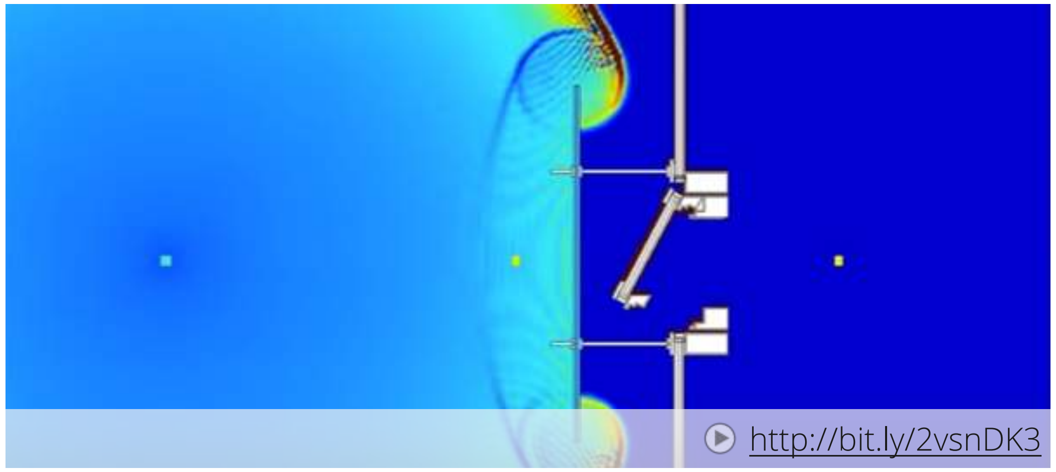
SOLAR SHADING & ANGLED FACADES

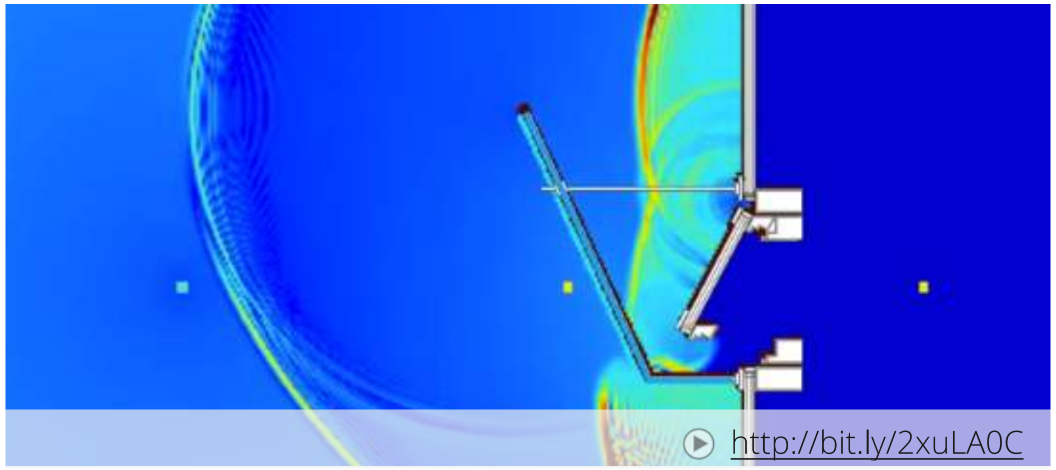
A baffle does not need to be opaque in appearance.

The use of solar shading or angled façade panels are an excellent example of providing of noise control with the additional benefit of reducing overheating.

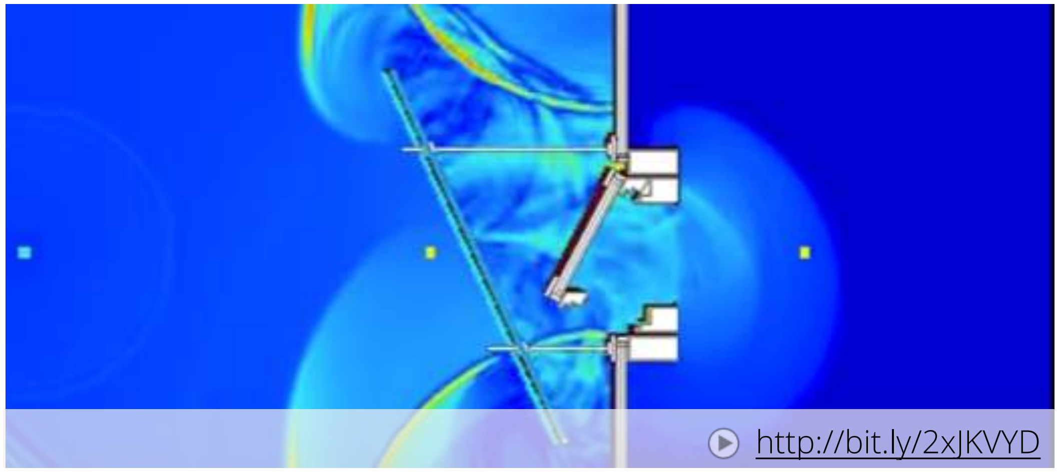
In some cases, these panels can be angled towards a specific noise source to provide a more effective sound barrier.

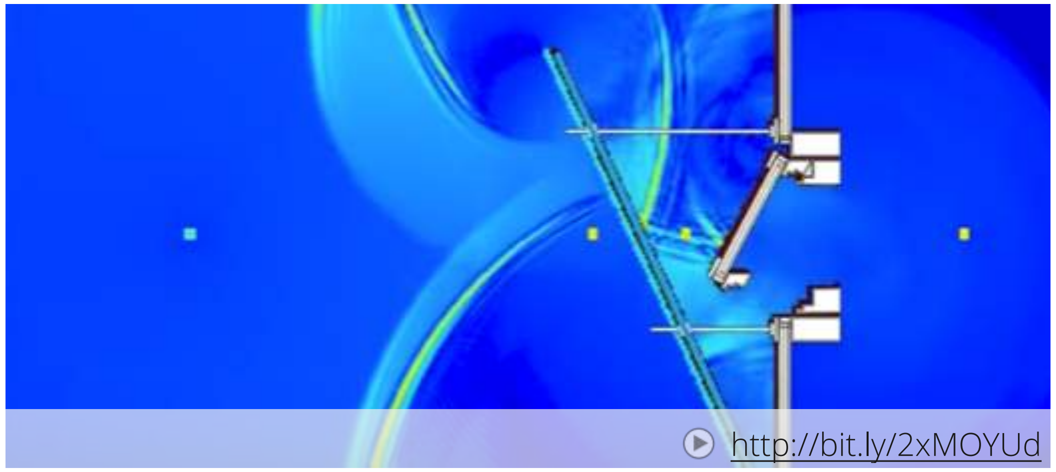
SOLAR SHADING & ANGLED FACADES





Click the links to see videos which demonstrate the effectiveness of different facade designs



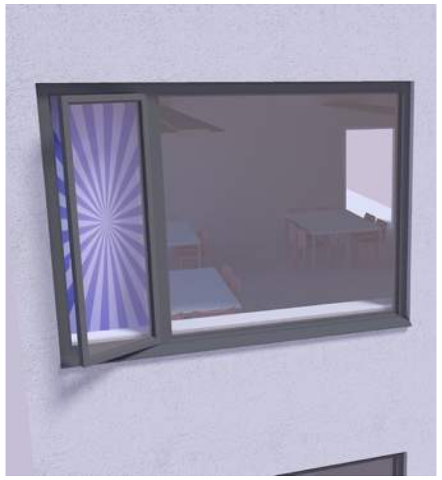


INTERNAL BAFFLE

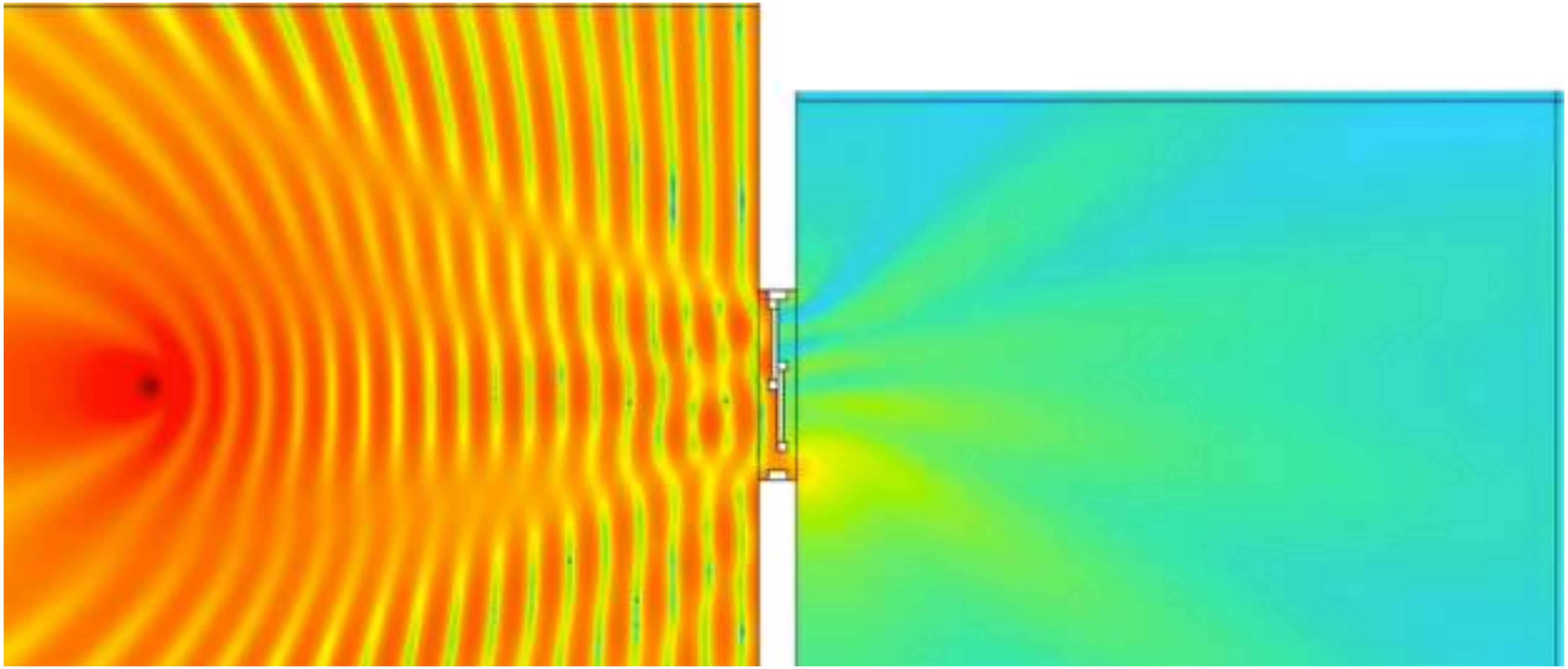
Internal baffles can be as effective as external baffles. As illustrated it is important to consider that light does not always need to come in through an air vent. The illustration opposite shows an opaque air vent adjacent to a conventional window.

An opaque baffle can be beneficial through being able to place acoustic absorption into the baffle or window reveal, obscured from sight, to further improve performance.

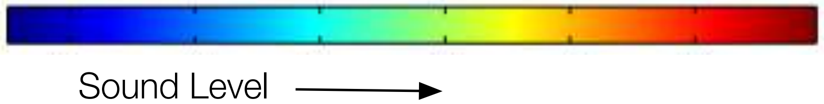
A transparent baffle, or a second pane of glass to create a secondary glazed system, is also an option, and is regularly done in listed buildings.



INTERNAL BAFFLE



This video shows the impact of an internal baffle on sound reduction of an open window.



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CONCLUSIONS

- *Current assessments are based on dated simplistic performance data of 10 - 15dB for an open window, limiting the use of natural ventilation.*
- *Research by Napier University and MACH Acoustics shows that an open window can actually achieve from 12-23 dB, with the same open area, depending on the window type.*
- *Therefore a further 20-40% of buildings could be naturally ventilated.*
- *Even greater performance can be achieved by the creative design of window frames, internal and external baffles, aesthetically disguised and with other potential benefits in thermal and energy performance.*
- *MACH use a variety of testing and modelling methods with a holistic approach to design, looking at acoustics, ventilation, thermal and energy together.*

GET IN TOUCH

Get in touch via info@machacoustics.com

or give us a call on 0117 944 1388

We are always happy to provide a quote for our services or simply discuss how the principles in this document can be incorporated into your project, so please feel free to get in contact.

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