BBC GLASS STUDIO DESIGN

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1 INTRODUCTION

In 2008 Munro Acoustics was commissioned to design a prototype broadcasting studio with walls made entirely of glass. Following substantial modelling and testing in the new extension to Broadcasting House the BBC has commissioned a full production design for installation within the organization. The studio design is both innovative and cost effective, with several engineering solutions rarely seen in acoustic applications.

The project follows on from another BBC project, 'The Production House of the Future', that resulted in an installation at BBC World Service in Bush House.

The author will present an overview of the acoustic design challenges and the successful outcome of the projects

2 INITIAL DESIGN CONSIDERATIONS 2005

2.1 The Production House of the Future

The design of sound studios has always been driven by a combination of technology, acoustics and, consequently, operational format. The objective of the PHoF project was to establish criteria for broadcasting in an open environment, without walls or demarcation between presenters and editorial staff. An initial assessment quickly showed that this was an unrealistic starting point with even substantial barriers and spatial separation unable to make an effective degree of attenuation against diffused and multi-source sound-fields. Some basic, acceptable values were established as design objectives such as a total, background noise spectrum of NR30. A value of NR25 was considered an acceptable steady state condition and thus the project began.

2.1.1 Development Constraints

Although the initial assessment was to be conducted at Bush House (World Service) it was understood from the beginning that the design should satisfy future expectations for other BBC News projects. As virtually all future projects were to be installed in large open plan environments with a strong desire to maintain an open aspect with minimal visual impairment, a glass walled design was strongly favoured. Several other factors had to be considered for the design to be acceptable as a ‘drop in’ throughout a standard construction environment.

- o Structural load limits within a open plan office space
- o Heat loads and ventilation
- o Vibration and noise from typical raised flooring
- o Fire and safety regulation conformity
- o Flexibility of construction for different operational layouts

- Ability to vary acoustics for a variety of layout and applications

3 INITIAL RESULTS

The first production version of the studio was designed as a trapezium with a highly absorbent long (base) side that would receive all early reflections and eliminate flutter. The 'dead zone', as it became known, would also house a fan coil unit and some technical, rack mounted equipment. Figure 1 shows the ETF plot for the prototype which gave remarkably even decay from 100 Hz upwards. Figure 2 shows the decay curve at 1 kHz.

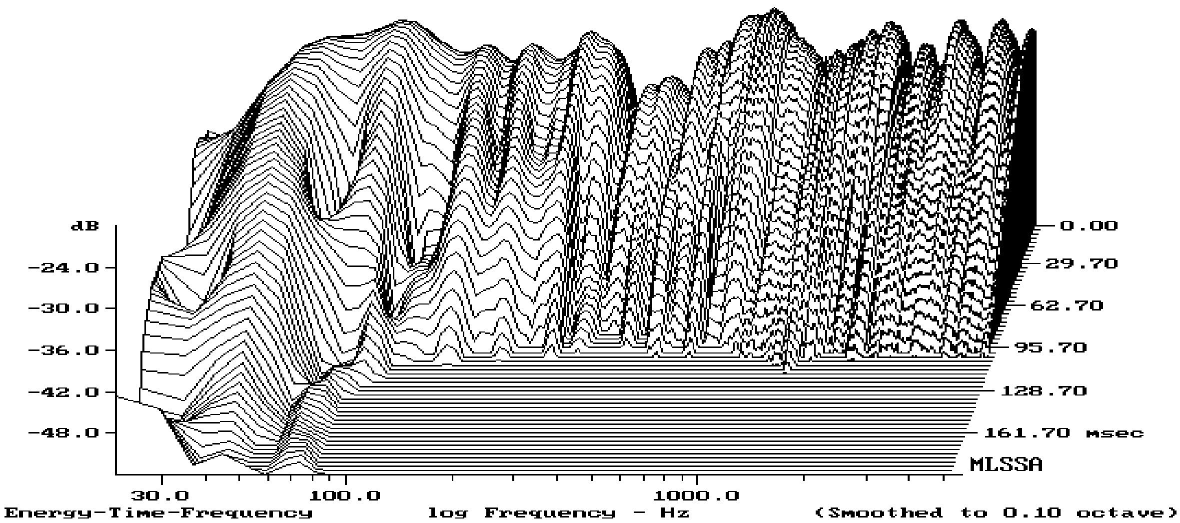


Figure 1 Energy-Time-Frequency plot for prototype

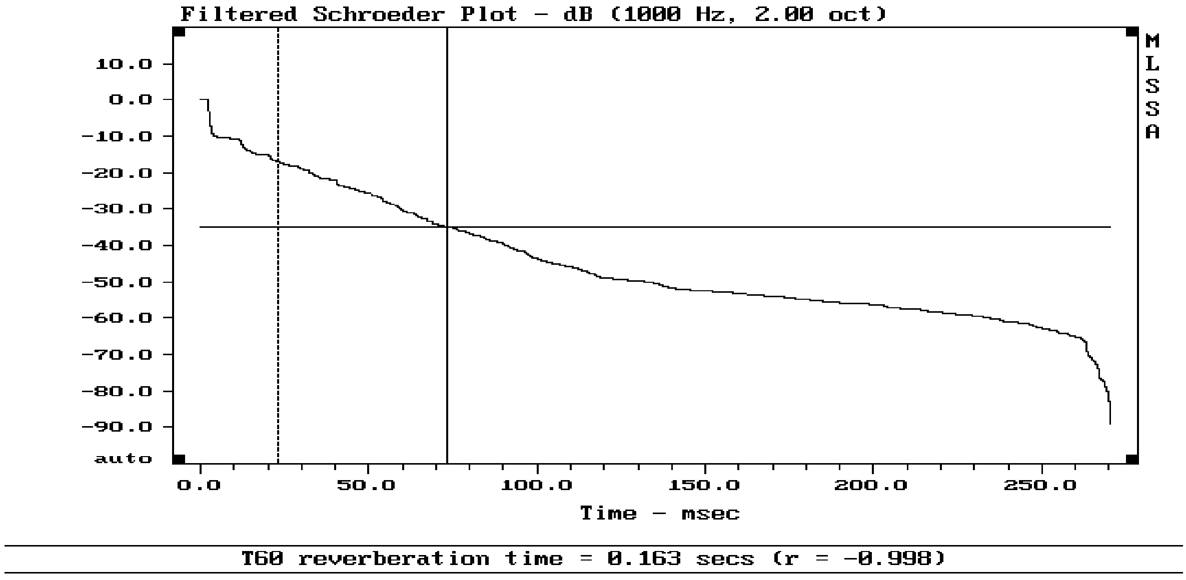


Figure 2 Schroeder decay curve at 1 kHz with 2 octave bandwidth

The initial performance of the isolation shell was less satisfactory with several deviations from the expected values achieved by the laminated glass in a laboratory test. Figure 3 shows the prototype sound insulation plotted against laboratory data. The laboratory test shows better low frequency performance than the prototype, and a single-figure value of R_w = 43 dB compared to D_w = 38 dB.

It was found that the isolation of the final installation was consistent with the prototype, but with some variation at low frequencies. Figure 4 shows sound insulation measurements from several rooms compared with the prototype result.

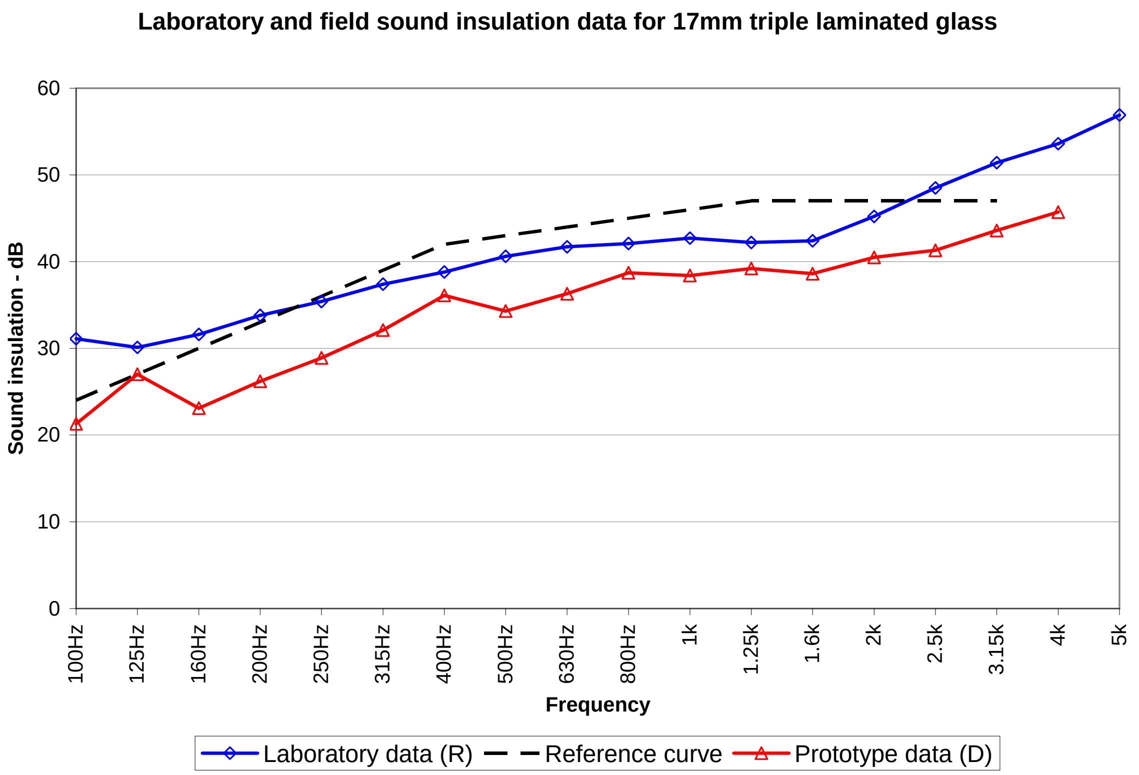


Figure 3 Laboratory and field sound insulation data for 17mm triple laminated glass

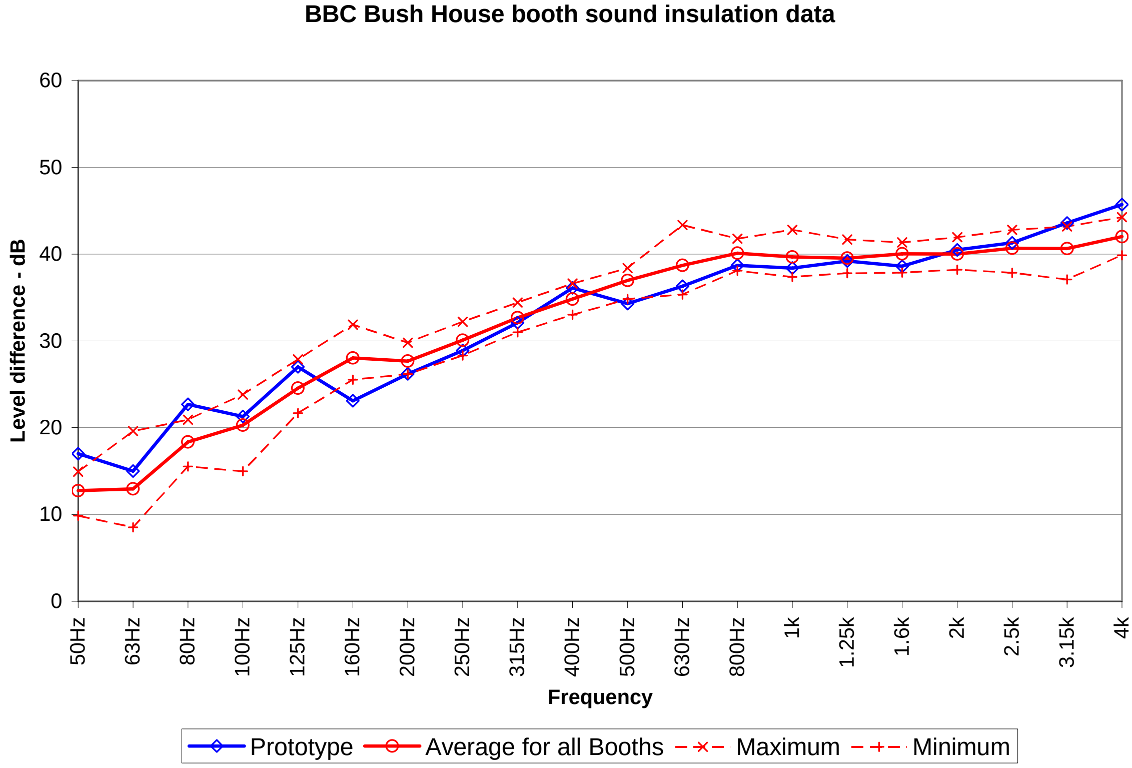


Figure 4 Sound insulation data for Bush House studios

Further investigations lead to the conclusion that the glass door chosen for the project did not seal sufficiently well to give consistent results, and the ceiling panels were not heavy enough to maintain low frequency performance to match the glass. The Bush House studios were also built directly onto a hard wooden floor with carpet overlay and a certain amount of flanking transmission was inevitable. There was no doubt that a design target of D_w = 40 dB or better could be achieved.

4 GENERIC DESIGN CONSIDERATIONS

Figure 5 shows the well established spectrum for speech and masking noise as published by Beranek [1] and others. The ANSI curve is for standard speaking level and raised speaking level it is about 10 dB higher with a similar spectrum. All levels are equivalent to L_{max} at 1 m.

Figure 6 shows the summation of the relevant BBC noise criteria curves in use at the time (subsequently modified) with the predicted sound insulation performance of the glass box studio. This gave a reasonable indication of the acceptable noise spectrum in the open plan newsroom environment.

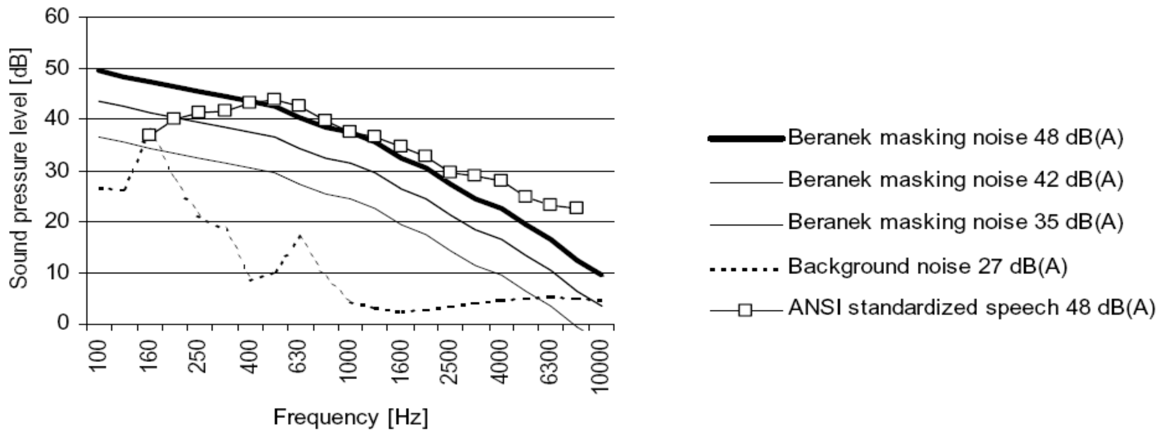


Figure 5 Speech Level Prediction

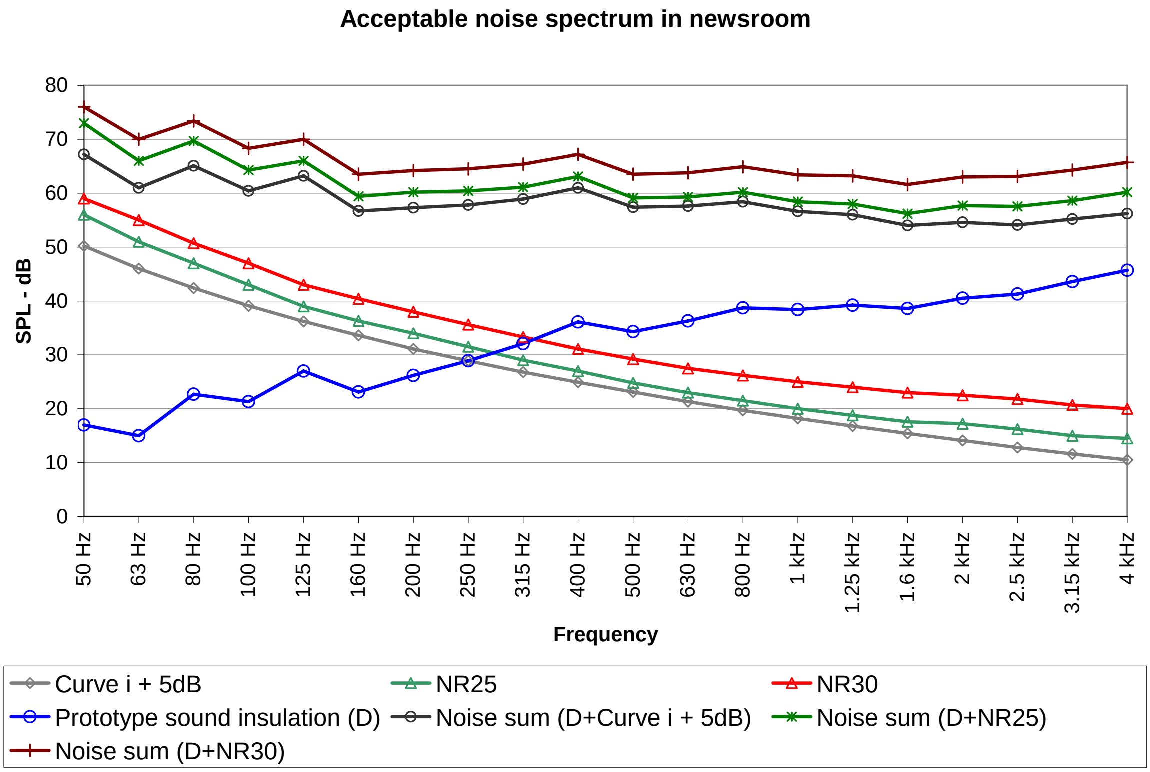


Figure 6 Prediction of acceptable newsroom noise spectrum

The resulting noise level of approximately 65 dBA is comfortably higher than that likely to be experienced on the newsroom floor. On this basis the design value for the steady state ventilation noise in the studios was agreed at NR25, which is between the GT2 and GT3 curves of the BBC acoustic specification [2]. The reason for this was to introduce a degree of noise masking so that any minor, short duration intrusions into the studio would be un-noticed by presenters. It should be stated at this point that all the thresholds of acceptability for noise and on-air intrusion have been tested over a considerable period of time within the BBC and subsequent operational response has been both positive and encouraging.

5 DETAILED DESIGN

The work at Bush House had highlighted several weak points in the initial design that have largely been corrected on site, and the studios now have several successful years of operation behind them. The greater challenge was now clear – to develop the design to the following criteria:

- A fully modular construction using pre-formed panels and minimal on-site disruption
- Self contained cooling and ventilation using only (but not connecting with) available ambient air-conditioning.
- A fully self supporting floating floor and structural frame
- Acoustics to RT1 (100 Hz to 5 kHz) with provision for additional LF absorption to 50 Hz
- Isolation to GT3 with GT2 as an operational option with controlled ventilation noise
- Variable acoustic treatment for individual situations
- Not to exceed typical office grade maximum floor loading limits
- Provision for in-floor and high level cable routing and hardware fixing
- Fully transportable and adaptable to a new location

It became obvious that cooling the studios with the available chilled beam systems used throughout all new BBC buildings would be challenging. It is beyond the scope of this paper to explain the design in detail but in essence it consists of an electronically-controlled fan on the isolation shell roof supplying pre chilled air drawn from the ceiling void, at a rate sufficient to balance the studio heat load. Both the chilled air and passive extract are fed through attenuators built into the ceiling. The fan speed is the only means of control and noise limits must be set accordingly. Under normal circumstances the resulting noise spectrum would match the GT2 contour but higher occupancy (and load) would necessitate an increase to GT3.

After a great deal of debate it was decided that the glass wall construction should be two sheets of PVB laminated glass in a customised frame extrusion. One fact became clear in that there are many fundamental and harmonically related resonances in all glass structures as can been seen by results shown in Figure 7.

The solid upper curve is the predicted performance, using the available literature for calculating mass, stiffness and dimensionally critical related resonances. It can be seen that the best performing systems fall well below the theoretical values for a 10.8 / 50.0 / 12.8 mm combination.

However the prototype format performs very well, especially in the dominant male speech octave of 500 Hz. A field test showed that low frequency performance actually exceeded the calculated value but that may have been an experimental error, affected by site acoustics. The low frequency isolation is not as critical in the performance criteria as the studios are to be used almost exclusively for speech and the low frequency background noise level in the studio, with ventilation running, is below GT1. In fact a little more masking effect, higher fan speeds might be advantageous.

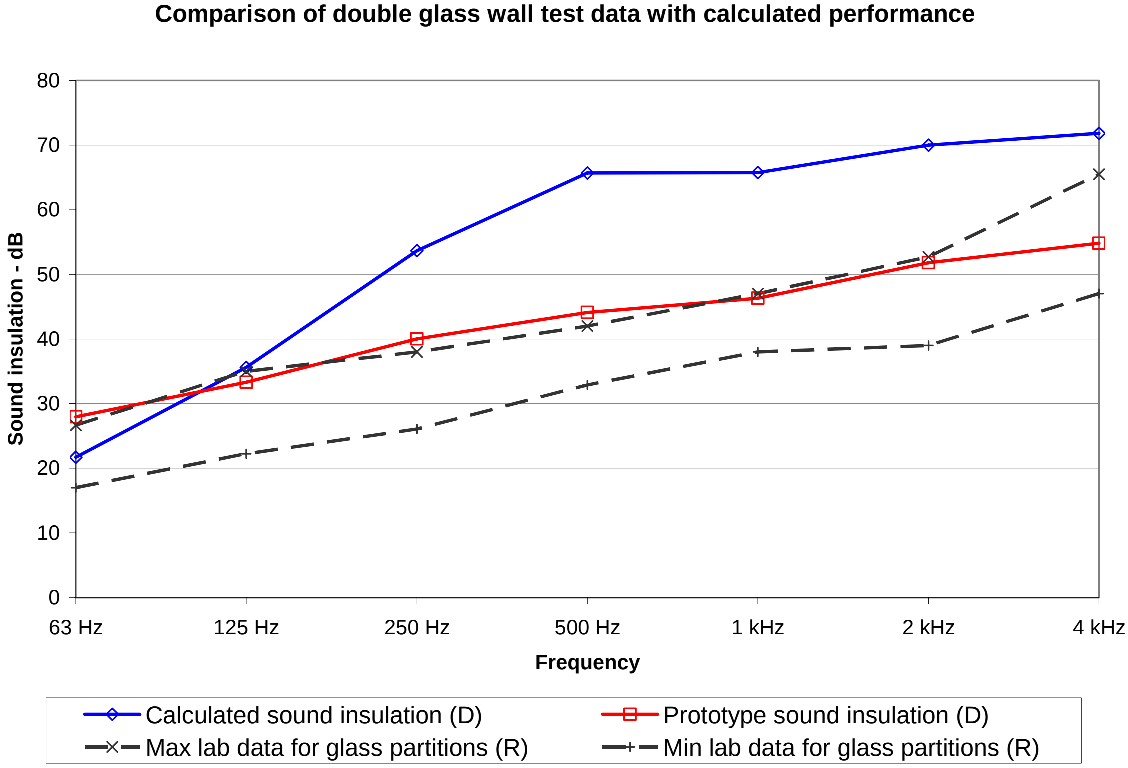


Figure 7 Comparison of double glass wall test data with theory

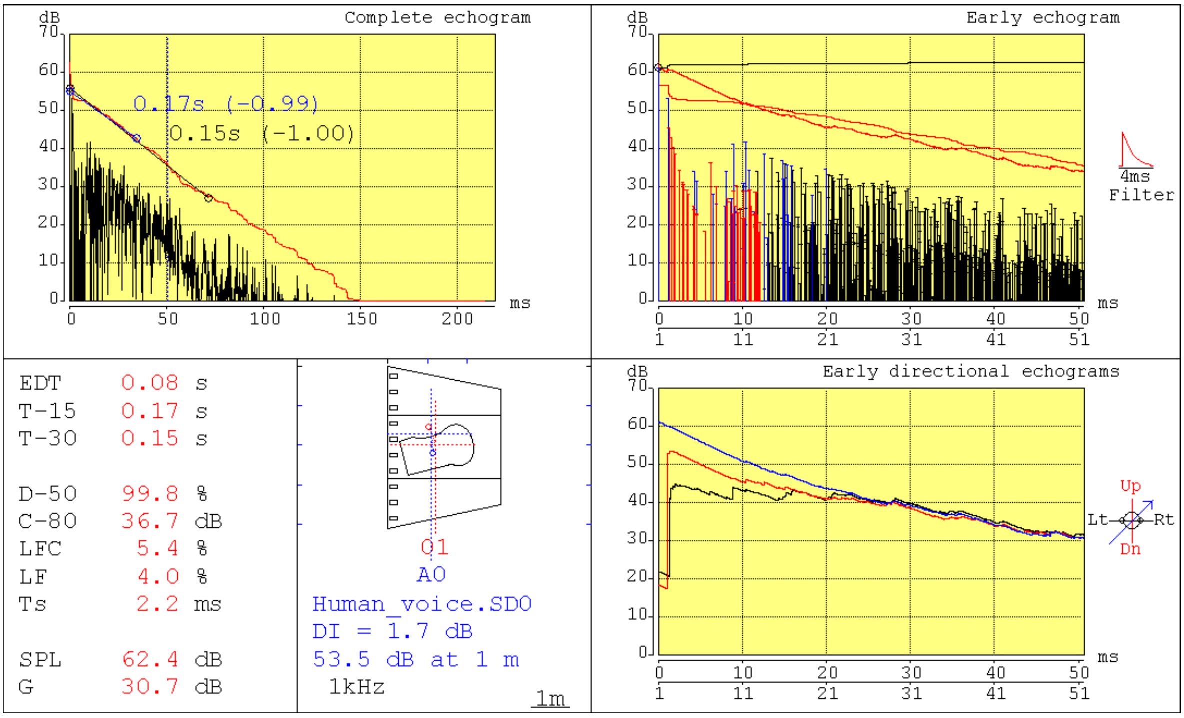


Figure 8 CATT model of prototype

6 FINAL PROTOTYPE

After several months of design and planning meetings the final prototype was erected in the summer of 2009 at BBC Egton House. The time window was exceedingly short with the whole construction, testing and removal process occupying no more than two to three weeks; a good test of the logistics as well acoustics.

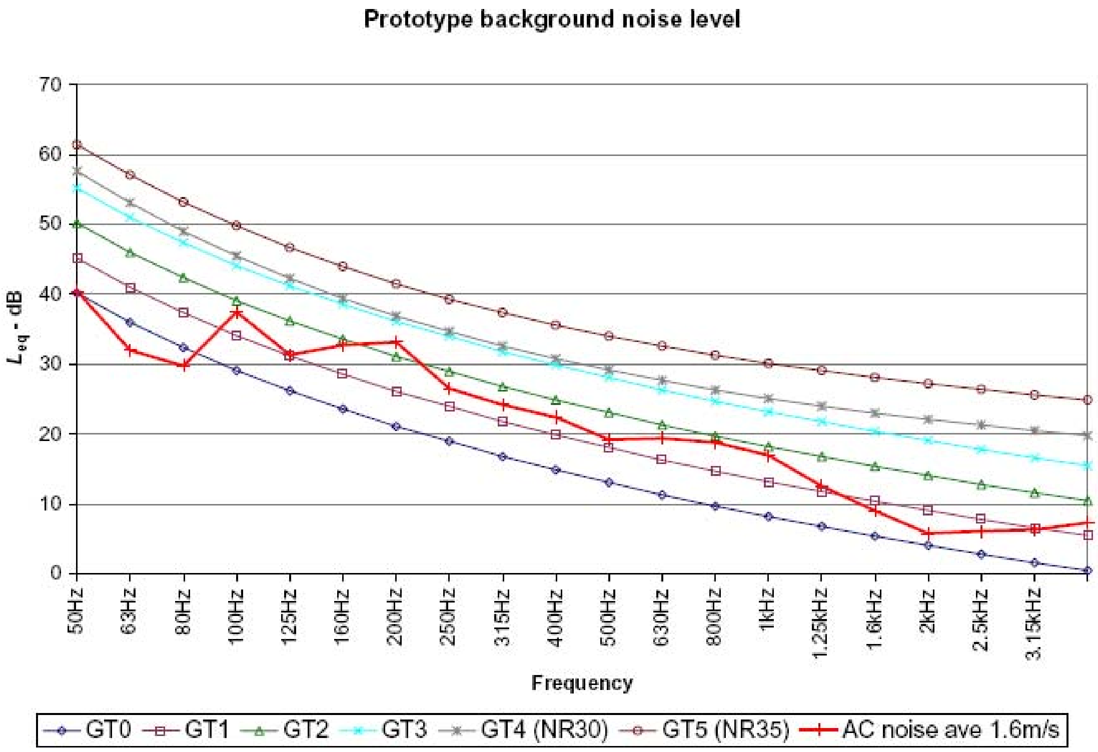


Figure 9 Measured steady-state noise level

The steady state noise was measured with the fan speed set at 1.6 ms^{-1} delivery at the supply grille, see Figure 9. This is the correct volume flow for the predicted heat-load of up to 700W and the in-coming air temperature differential predicted for the chilled ceiling. Sound insulation and reverberation time measurement results are shown in Figure 10 and Figure 11, respectively.

The results of the prototype testing were in line with the design values and predictions. Very few changes have been deemed necessary for the production version. The prototype was visited by every interested party within the organization and the design has been accepted for adoption at Broadcasting House W1 project.

Standardised level difference according to ISO 140-4
Field Measurements of airborne sound insulation between rooms

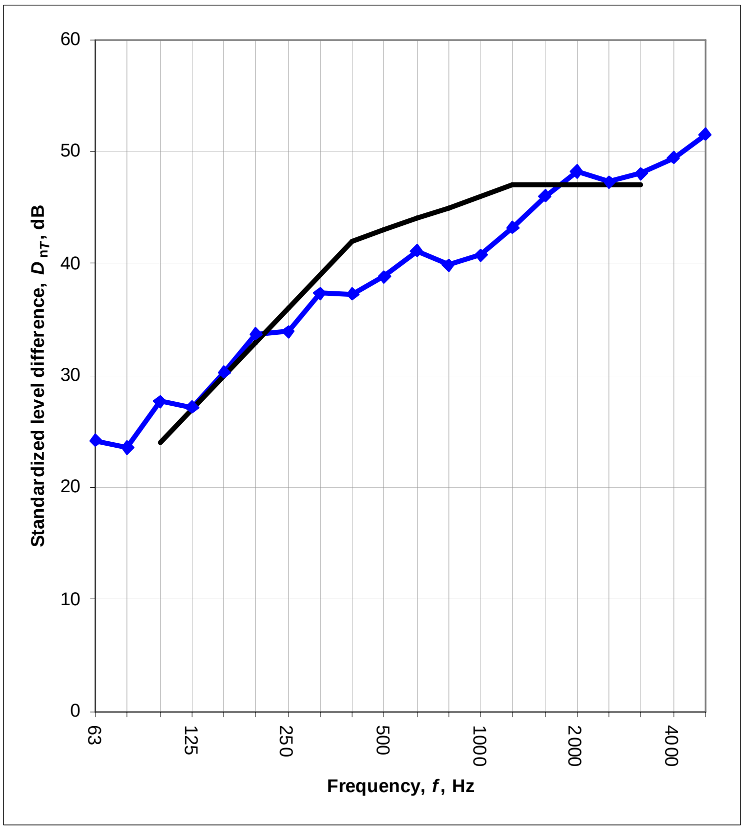
Client: BBC W1 Date of test: 21 Aug 09

Description and identification of the building construction and test arrangement, direction of measurement:

Prototype - Newsroom

Source room volume: m3
Receiving room volume: m3

Frequency f Hz	D_{nT} (one-third octave) dB
50	21
63	24
80	24
100	28
125	27
160	30
200	34
250	34
315	37
400	37
500	39
630	41
800	40
1000	41
1250	43
1600	46
2000	48
2500	47
3150	48
4000	49
5000	52



Rating according to ISO 717-1:
D_w = 43 dB
Results based on field measurement
results obtained by an engineering method

No. of test report: BBC-02 Name of test institute: Munro Acoustics
Date: 21 Aug 09 Signature:

Figure 10 Final prototype sound insulation performance

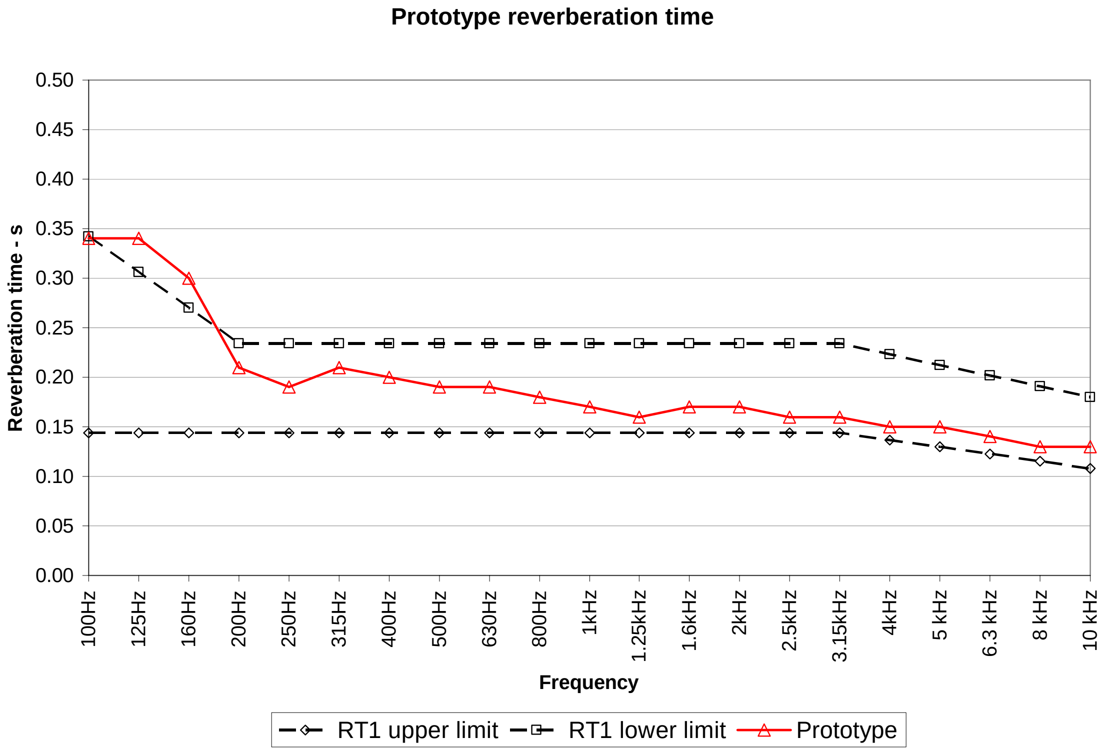


Figure 11 Final prototype reverberation time

Very special thanks are due to everybody directly involved in this project. A lot of effort was required to make it happen and it took a great deal of determination to see it through to a very successful conclusion.

7 REFERENCES

1. Beranek, L – *Acoustics* – 1986 Edition pp408

2. Cole, R – *BBC Facilities-Acoustics-3 Internal Document* – October 2008