



The Grand Mosque in Abu Dhabi is one of the world's most spectacular places of worship, but such buildings make for notoriously difficult acoustic spaces. Lee Baldock looks at the expertise and technology that provided a grand solution . . .

Grand Designs

UAE - Officially opened during Ramadan in 2007, the Sheikh Zayed Bin Sultan Al Nahyan Mosque (or 'Grand Mosque' as it is more commonly known) is named after the founder and first president of the United Arab Emirates (UAE), who was buried at the site of the mosque in 2004. Large enough to house 40,000 worshippers and covering 22,412sq.m, this is no less than the third largest mosque in the world, following two Saudi Arabian structures in Mecca and Medina.

Of the 82 domes included in the Grand Mosque's architecture, the impressive main dome is indeed. One of the largest to be found in a house of worship anywhere in the world, it measures 32.8m in diameter, while the crown of the dome soars 87m above ground level.

Elsewhere, there is further evidence of grand designs. The Mosque is home to the largest hand-woven carpet ever created (at an estimated cost of £2.8m). Designed by Iranian artist Ali Khaliqi and made by around 1,200 weavers, 20 technicians and 30 other workers, the carpet measures 5,627sq.m and comprises 35 tonnes of wool and cotton. Also to be found are seven copper and gold-plated chandeliers imported from Germany. The largest of these is the largest in the world: it measures 10m in diameter, 15m in height and is adorned with one million Swarovski crystals.

More than 3,000 workers and 38 contracting companies took part in the vast mosque's construction. Work began in the early 1990s, with the concrete shell of the building completed in May 2002. Naturally, the architectural design of the mosque is focused on leaving a lasting impression on the worshipper. The central prayer hall, which can hold up to 9000 worshippers, measures 50m x 55m with a stretch of 33m from floor to ceiling. This stretch is interrupted only by the arched structure supporting the base of the mighty dome.

Such an impressive interior could also be an audio installer's nightmare. The chosen materials offer huge amounts of reflective surfaces, with very few sound absorbing materials used anywhere. Over the long duration of the project, a number of audio consultancies were called in to advise on the various phases of development. PMK International, based in the US but with a Middle East office in Dubai since 2002, was consulted in 2004-2005 and was also called upon to work on sound systems design reviews in 2006.

A number of acoustic treatment measures aimed at reducing reverberation times were recommended to the Abu Dhabi Works Department. In order to address the worst acoustic characteristics of such spaces, it would be usual to specify that the carpet should have an underlay and a denser pile than those normally used in mosques, in order to increase the low frequency absorption. However, in cases where the cost of the carpet runs into millions, other solutions may need to be found.

Measures that *could* be implemented included the laying of a special concrete, with improved sound absorption characteristics, beneath the carpeted area.

PMK also recommended a column speaker solution and listed a number of manufacturers and models based on price and performance. Called in to manage the sound system design and tenders process was renowned German acoustic consultant Dr Wolfgang Ahnert, of ADA (Acoustic Design Ahnert). ADA established its Middle East office in Doha, Qatar in 2007, with a satellite office in Dubai.

Architectural fixes aside, it is the sound reinforcement solution which offers the greatest advantages to the acoustician. Developed with sophisticated EASERA modeling, the chosen solution used high-mounted directional line array PA loudspeakers from Dutch manufacturer Duran Audio. Dr Ahnert says: "We expected, as submitted, a reverberation time of around 2.5 seconds, but the first measurements with our EASERA system showed more the 4 seconds in the mid frequency range. So we were happy to have selected from the beginning modern, controllable line arrays - only that way was it possible to suppress the reverberation in the huge space."

The slimline design of the company's AXYS Intellivox steerable arrays allows the loudspeakers to be sensitively incorporated into the architecture, without creating a visual distraction from the overall design of the interior, while the computer-controlled vertical directivity of the units enables the fine adjustment required to minimise reflections. At the same time, different directivity patterns can be stored in on-board memory to allow the system to be adjusted according to the varying numbers of worshippers using the space at any particular time, and even whether they are standing or kneeling.

Duran Audio's Digital Directivity Control technology (DDC), and Digital Directivity Synthesis (DDS) technologies provide a high level of finesse for the system designer in these environments. Control is via WinControl software, over an RS485 network, which provides access to all parameters affecting the vertical dispersion of the array, as well as volume control, parametric EQ, delay and AVC functions.

The main body of the mosque incorporates 14 AXYS Intellivox DS280, measuring 2.8m in length, and six of the shorter (1.2m) DS115 columns. Elsewhere, the main entrance hall area and the two side entrance halls are each covered by a single DS280 column, while a further two DS280s cover the women's prayer area. Additionally, Community horns cover the outdoor areas, including the Courtyard and the minarets. The system is also linked to a Bosch Praesidio emergency voice alarm system.

Gulf Electronics Company (GEC) was chosen to supply, install, test and commission the system. All the AXYS Intellivox loudspeakers were supplied to GEC by Duran Audio in the Netherlands. GEC's Imad Abdulnour told me: "The installation itself took around two months between cable pulling, speaker fixing and connecting, with a team of eight people working on it. There was absolutely no problem in the installation, as those speakers are very easy to install: you just need to connect a data cable to program the speaker from a remote PC, an audio cable for the audio signal and a power cable for the amplifier inside the speaker. After the installation was completed, Duran Audio came for final programming, measuring and fine-tuning. The client was very satisfied with the result."

Dr Ahnert concludes: "The Duran Audio systems do a wonderful job in the mosque . . . The fine tuning done recently shows everywhere an STI greater than 0.5 - even in the empty hall."

• *The Abu Dhabi Tourism Authority has made provision for guided tours of the building for muslims and non-muslims alike in an effort to promote cultural and religious understanding. Visit www.visitabudhabi.ae for more info.*

• *ETC and Martin Pro are working on the external lighting installation in association with Speirs and Major Associates, with programming scheduled for early in the new year. Look out for more details in our April 2009 issue.*

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