The house system at St. Mary's consists of two large format arrays (concealed for aesthetic reasons) and custom column-mounted distributed columns

The Gold Line TEF20 Speech Intelligibility Workshop was held on October 11-13 in Chicago. About 50 audio people from around the world assembled to measure and correlate live listener intelligibility tests with measured data. The Workshop was staffed by Don Keele (Harmon-Motive USA), Dr. Herman Steeneken (the Netherlands), and Peter Mapp (England). Doug Jones (Columbia College) was the Workshop chairman.

Presenters at the TEF Workshop, Chicago: (left to right) D. B. "Don" Keele, Senior Engineer, Harman-Motive; Prof. Doug Jones, Chairman, Audio Department, Columbia College, Chicago; Peter Mapp, Principal, Peter Mapp Associates, Colchester, England; and Dr Herman Steeneken, Senior Research Scientist, TNO, Human Factors Group, Netherlands.

Prior to the site tests, each start member did a presentation on their particular specialty regarding intelligibility. This formed the backdrop of theory that would guide the field measurements and listening tests and served to provide a basis for post-workshop discussions of the results.

The Venues

Two venues were selected based on their ongoing challenges to speech intelligibility. St. Mary's Catholic Church (pictured above) and St. Helen's Catholic Church (opposite page) are both reverberant spaces with existing sound systems. These were complimented with additional loudspeakers, allowing several approaches to be

compared in each space. The 50+ attendees were divided into teams. Each used a TEF20 to measure numerous listening positions in each space. One of the teams was assigned the task of modeling the room in EASE™ 4.0 to investigate the correlation of predicted data with measured.

St. Helen's Catholic Church served as the staging ground for the workshop. The group sessions were held in the bingo hall. Portable loudspeakers were flown in the sanctuary by Rent Corn of Chicago. They included high-Q (Community M4) and medium-Q (Renkus-Heinz) devices flown from portable lifts.

Portable lifts were used to place the test loudspeakers at St. Helens Catholic Church.

St. Mary's is a much larger space - a traditional cruciform cathedral. The house system was designed by Jim Brown and installed by RC Communications of Chicago. Two Intellivox™ line arrays were added for the workshop. Attendees had the opportunity to perform numerous listening tests and measurements on the systems.

From Gold Line's Greg Miller: *"We were pleased to support the program as one of the Sponsors, but Gold Line could not have undertaken a project this large without the massive and generous support of the industry. Substantial consulting time was donated by Jim Brown. Time and gear were provided by Ron Steinberg/Rent Corn. Shure and TOA both donated gear and paid the time and expenses for their staff to attend and assist with the project. The gear was then retained by the churches, with a positive benefit to all of their parishioners. Harman international made it possible for Don Keele to be with us. Peter Mapp donated his time. Same for Don Eger, Bruce Olson and Blair McNair. Part of the money came from attendee fees, but in the end it was the sponsors who made this possible."*

Bruce Olson (left) and John Murray provided technical support for the workshop.

St. Mary's Church Chicago - Approximately half of the TEF Workshop class assembles in the impressive nave of St. Mary's Church.

St. Mary's Church, Chicago: (at keyboard) Bruce Main, President, Vector; (seated next to him) Robert Coffeen, Professor, Department of Physics, University of Kansas; (standing, left to right) Patrick Joyce, Simplex-Grinell; Mike Stewart, Professor, Fullsail University; and Rusty Crocker, Engineer, NB Traylor & Associates.

The Process

Intelligibility testing is not a trivial task. The benchmark for any method has always been the live listener. Word list testing was done at the workshop to provide a standard to which to compare the instrument tests.

Speech intelligibility ratings are basically recipes which ratio some or all of the following ingredients:

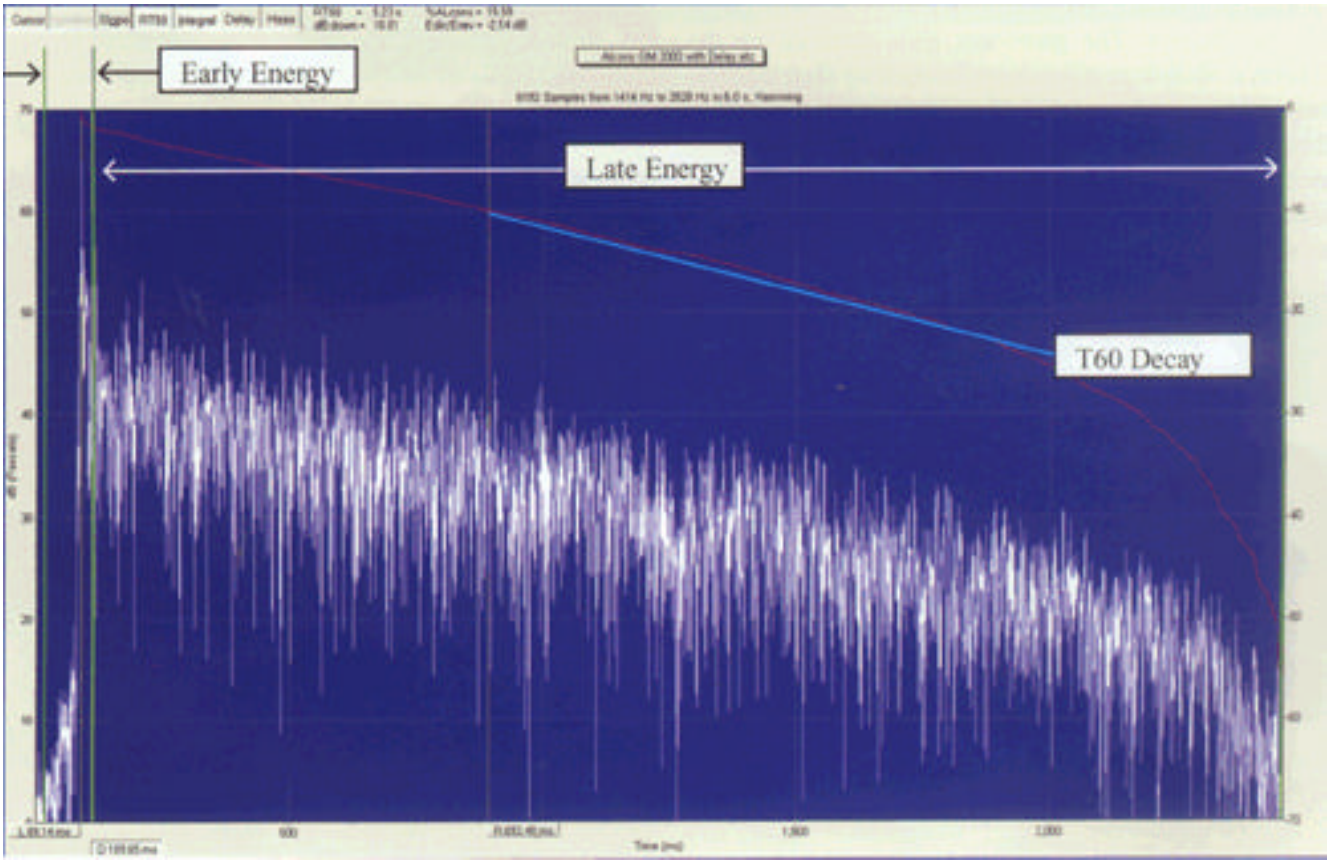
ED - The early sound energy
ER - The late sound energy
EDT - The early decay time
T60 - The late decay time
Noise - Ambient room noise

An analyzer must be able to measure these parameters and process the results into a score that correlates with how a human listener might judge the intelligibility. The TEF analyzer is well-suited for this purpose, since it allows these and other system/room parameters to be measured accurately.

The core measurement used at the Intelligibility Workshop was the Energy-Time Curve or ETC. This is basically a very sophisticated hand-clap test. It displays how the sound system and room would respond to an impulsive stimulus fed through the system. Due to the drawbacks of testing with impulses (non-linearities, poor signal-to-noise ratios) the test is performed with a swept sinusoid (chirp) and the ETC is determined mathematically. This method pours significantly more energy into the room than an impulse would, and does not drive the system into non-linear operation.

The measurement shown below was made at St. Mary's church. The system was swept with a sinusoid that spanned the 2 kHz octave band (1414 Hz to 2828 Hz). The duration of the sweep was 6 seconds. The signal-to-noise ratio achieved by the swept sine process is apparent by noting the vertical scale. The energy decay actually extends down into the ambient noise floor of the space, showing a major benefit of this mode of testing. The graph shows the energy storage characteristics of the space for this octave band at one listener position.

Not all of the energy decay is useful for communication. The "D" cursor divides the early energy from the late energy - the early being useful and the late being a detriment to communication. The placement of this cursor at 20 ms after the first sound arrival is somewhat subjective, the typical early span ranging between 7 ms (conservative) and 35 ms (ambitious). The TEF software automatically sets the cursor, but the user is free to move it. In effect, by setting the cursor the measurer is saying that any energy arrivals to the right of the cursor are a detriment to communication. The left (L) cursor and right (R) cursors mark the early-decay time (EDT) for this seating position. The EDT describes the time required for the sound energy to drop 10



dB from the level of the first arrival, extrapolated to 60 dB of decay. Short EDTs generally mean better communication, since room falls off more quickly and masks the information to a lesser degree. If the cursors are placed further into the time record (say, L at 300 ms and R at 2 seconds) the classical T60 is determined. The T60 is the time required for the reverberant field level to drop by 60 dB from the cessation of a steady sound source. The goal of a sound system is to make the EDT less than the T60, which should enhanced the talker's ability to communicate with the listener in the presence of a reverberant sound field.

With cursors in place, the ED - ER (early-to-late energy ratio) is displayed (positive numbers are desirable) as is the Percentage Articulation Loss of Consonants (%Alcons). The goal of the sound system is to make %Alcons as small as possible and ED - ER as large as possible.

The ETC is also used to perform another intelligibility test, the Speech Transmission Index or STI. This test measures ETCs at seven octave bands, as well as the ambient noise of the space. The results are processed into an intelligibility score that ranges from zero (bad) to one (excellent). The test can be abbreviated by performing the measurements at the 500 Hz and 2 kHz octave bands only. This test is known as the Rapid STI or RASTI.

During the workshop, teams made hundreds of ETCs at various listener positions to compare the performance of the various loudspeaker configurations. When compared with live listener tests, more is learned about how humans process sound energy and derive information in the presence of noise and reverberation.

Conclusion

The importance for intelligibility testing of public address systems was underscored by the events of September 11. System designers play a major role in the effectiveness of speech warning systems. They must understand the criteria that are important to communication and be able to meet those criteria in a given venue with a system design. This requires that the designer become proficient in testing the intelligibility of systems. Expertise in this area will lead directly to sound systems that are better at conveying information to the listener.

The subject of speech intelligibility remains a controversial one. All agree that some good tools are available for evaluating systems, but also that much work remains to be done in developing measurement systems that produce intelligibility scores that correlate with live listener tests. *pb*