Computer-Based Prediction of Speech Intelligibility for Mass Notification Systems

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Speech intelligibility has been a concern in public buildings since at least the time of antiquity. In the twentieth century, as urban populations and places of public assembly grew dramatically, speech intelligibility also became a concern in the field of public safety. The need to forewarn the public of an emergency and guide them to safety in an actual event led to the establishment of building codes and regulations throughout most of the world. Given its indisputable and indispensable value as a method of communication, speech as a warning and information channel has continued to grow in importance in the first decade of the twenty-first century.

As a result of these trends, and beginning in the middle of the twentieth century, efforts by scientists and engineers were made to predict intelligibility from physical measurements of acoustical parameters. At the same time, efforts were made to predict these values in advance of room construction or sound equipment installation. As with so many other technologies, over time these methods of prediction have for the most part become increasingly sophisticated and accurate.

All of the prediction methods rely on the fact that speech intelligibility is essentially determined by the ratio of helpful speech sound to unhelpful or interfering sound, whether that interfering sound be from excessive reverberation, the distortion caused by overdriven electronics or loudspeakers, or ambient noise. Early prediction models relied on the measurement of the ratio of speech to interfering noise in the various frequency bands comprising speech. However, these efforts did not account for the effect of reverberation and echoes on speech, factors of obvious concern to engineers designing and installing public address systems in large public spaces. Early formulas that included reverberation were published in the 1970s but were often shown to be inadequate when tested on the wide variety of loudspeakers, loudspeaker configurations, and acoustical conditions typically encountered in large public spaces. Early computer programs that implemented these simplistic formulas were fast at making the computations, but did not address the underlying problems with the formulas themselves.

In the late 1970s a new and comprehensive approach to predicting intelligibility emerged from TNO, a highly respected research laboratory in The Netherlands. Their research ushered in the modern era of speech intelligibility prediction. The Speech Transmission Index, or STI, accounted for all of the major factors affecting speech intelligibility and was shown to be reasonably accurate. A number of computer programs for designing acoustical spaces and sound systems began to include STI prediction, and at least one was shown in a respected peer-reviewed scientific journal to be an accurate predictor of the STI, and hence speech intelligibility in the majority of situations commonly encountered in acoustical and sound system design.

Today, it is possible for acoustical and emergency voice evacuation system designers to confidently predict speech intelligibility in most buildings using one of several computer-based design tools. Such prediction is essential in a climate where codes and regulations require that voice evacuation systems meet minimum intelligibility requirements. Moreover, very fast, relatively inexpensive, and easy to use STI measurement tools have recently been introduced, making verification and enforcement possible for the first time. Finally, research continues in this field: the STI itself is being refined and made more accurate, and computer-based prediction tools are being improved to include some of the more challenging acoustical spaces.

In summary, the beginning of the twenty first century marks a time when science and engineering has made it possible for design, construction and public safety officials to set and meet meaningful speech intelligibility standards in most buildings and on a global scale.

Recommended reading:

Past, present and future of the Speech Transmission Index, T. Houtgast & H. Steeneken, TNO Human Factors, 2002.

Accurate Prediction of Speech Intelligibility without the Use of In-Room Measurements, K. Jacob et. al., Journal of the Audio Engineering Society, April 1991.