Quantifying Public Address System Performance in a Public Transit Environment

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ABSTRACT

The Toronto Transit Commission (TTC) new Sheppard subway line is nearly complete. It adds 5 new stations and 6.4 km of tunnel to their system. From the beginning of the overall design of the stations, efforts were made to ensure the public would be able to understand public address(PA)announcements during revenue service and in emergency situations. The PA system design goal was a speech transmission index (STI) of 0.45 or 'Fair' intelligibility. As each station is completed, it is being measured using Maximum Length Sequences in a PC based measurement system in order to validate the performance of the PA and the station architectural treatment. The paper will discuss the PA system used, summarize the measurements, provide some assessment as to the performance of acoustic treatments used in the station finishes as well as comment upon the practical aspects of using the Dirac measurement system.

1. INTRODUCTION

The Toronto Transit Commission (TTC) is completing the new Sheppard Subway line,. The PA system is considered an essential part of the emergency response and alarm systems. As part of setting up the system design standards, the project concluded that an STI of 0.45 from the PA system was appropriate.[1, 2] This paper summarises measurements of the STI in the stations.

Table.1 Generally Accepted STI Numerical Ranges and Ratings

STI Range	Rating
Less than 0.3	Unsatisfactory
0.3 – 0.45	Poor
0.45 – 0.6	Fair
0.6 – 0.75	Good
Greater than 0.75	Excellent

2. STI TESTING

Testing is done using Dirac software from the Netherlands and currently distributed by Bruel and Kjaer, running on a Dell notebook fed by a Rion NA29E Type I sound level meter. The system uses Maximum Length Sequences to determine the impulse response of the station and PA. From the impulse response, the Reverberation Time, the STI and other acoustical parameters are then calculated. The system is calibrated to adjust for any limitations in the sound card and has a 60 dB Total Harmonic Distortion plus Noise ratio. STI is implemented in accordance with IEC 60268-16.[3, 4]

Two types of measurement were made. In the first, a high quality loudspeaker was used to measure the acoustics of the station alone. The microphone was typically placed approximately 6m from the PA speaker and STI and the Early Decay Time (EDT) were measured. Then the computer signal was fed into the station PA system and the STI and EDT of the full system and station were measured.

Three stations out of five have so far been completed to the point where they can be tested: Leslie, Don Mills and Bayview. They were substantially complete insofar as interior finishes were concerned. Platform dimensions were nominally 100 x 20 x 4m (including the rail area) and concourse dimensions 100 x 20 x 5m. The areas tested were the subway platform, the ticket concourse located above the platform area and the upper bus terminal. In each space four tests were made: with a single high quality loudspeaker approximately 6m from the microphone, to determine the station performance independent of the PA system, with the microphone 1m from a PA speaker to determine the PA system performance independent of the station acoustics and at locations 1.2m above the floor either under a PA speaker or halfway between sets of four PA speakers to determine typical performance at a patron's ear.

3. RESULTS OF TESTING

Table 2, gives the results of testing at Bayview Station. Tests were carried out through the station PA system and using the high quality loudspeaker (speaker, in italics). STI is given for male and female voices as described in IEC 60268-16[5]. Although the original work specified only a single STI, the new standard (1998) specifies both and it was decided that the most recent standard should be used.

Table.2 Bayview Station Results

Preliminary Results	Source	STI female		STI male		EDT 500
S upper concourse untreated between speakers	PA	Fair	0.45	Poor	0.42	3.28
S upper concourse untreated 1.5 m under speaker	PA	Fair	0.56	Fair	0.52	3.05
N ticket concourse between speakers some treatment	PA	Fair	*0.52*	Fair	*0.52*	1.76
N ticket concourse PSB at 8m pointing to microphone	*Speaker*	*Good*	*0.62*	*Good*	*0.61*	*1.31*
N ticket concourse PSB at 8m pointing up	*Speaker*	*Fair*	*0.57*	*Fair*	*0.56*	*1.36*
S ticket concourse treated - under speaker	PA	Good	0.63	Good	0.62	1.37
S ticket concourse treated between speakers	PA	Fair	0.57	Fair	0.55	1.8
platform between 2 speakers	PA	Fair	*0.45*	Fair	*0.45*	2.62
platform under speaker	PA	Fair	0.55	Fair	0.53	2.28

Several comments are in order:

The treated upper areas met or in many cases exceeded the requirement of STI 0.45, or Fair performance. The platforms met the criterion under the PA speakers and were marginally below between the PA speakers. Untreated areas, gave generally poor results. The PA speakers at 1m were tested at Leslie station and generally gave Good performance on the upper levels (with higher ceilings) and Fair performance at the Platform level.

4. CONCLUSIONS

It is concluded that main parameters affecting transmission of speech from the PA system, in approximate order of importance, were: reverberation of the space, dimensions, PA speaker placement, and PA system performance. In general the reverberation was adequately controlled to 1.5 seconds, but artificial reverberation from the row of PA speakers along the platform increased this. Clearly the acoustical treatment significantly improved speech intelligibility. The ceiling height was the most important dimension and interacted with the PA speaker placement to reduce speech intelligibility on the platform. This will require further attention. The PA system performed adequately, but the PA speakers, which were provided and installed separately, did not give usable output in the 125 Hz octave band, decreasing STI somewhat. They also did not have sufficient dispersion, allowing the intelligibility to decrease significantly between speakers. However it is clear that the acoustical treatment and specifying a good quality PA system have contributed significantly to providing better intelligibility of announcements for passengers.

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