COMPARISON BETWEEN COLUMN SPEAKERS AND FLAT PANEL SPEAKERS IN A METRO STATION BY ODEON

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1 INTRODUCTION

This paper summarizes the results of simulations for the sound pressure level (SPL) and speech intelligibility (STI) distribution in a metro station by flat panel speakers in comparison with the traditional loudspeakers. The modelling work was carried out to determine the advantages of a new integrate panel speaker system that has been developed by QinetiQ to enhance the quality of public address systems. The panel speakers are modelled both as point sources and surface sources in ODEON room acoustical program.

The flat panel speaker is very simply the concept of making a loudspeaker from a vibrating soundboard with the help of an exciter. Flat panel speakers are thin, lightweight and in principle can be in any shape and size. The flat panel speakers used for the simulations in this paper are of 180x25 cm dimensions.

Section 2 of this paper explains the modelling of the speakers in ODEON. The best method to represent the directivity of the QinetiQ flat panel speakers was investigated. Therefore, the speakers were modelled as point sources and as surface sources for comparison. The directivity data provided by QinetiQ is used as a guide for the modelling of the speakers as point sources.

Sections 3 deals with the description of the first simulation set-up and displays and discusses the simulation results. The room acoustic model of the metro station is prepared with traditional column speakers and QinetiQ flat panel speakers.

Section 4 describes the second set-up of simulations with absorption applied as ceiling treatment. The results demonstrate the amount of absorption necessary to reach average STI of 0.5 and ‘Average STI-standard deviation’ of 0.43 by column speakers and panel speakers in the metro station.

2 MODELLING FLAT PANEL SPEAKERS IN ODEON

In the ODEON room acoustical programme, sound sources can be defined as point sources, line sources or surface sources. How to model the QinetiQ flat panel speakers is an important question to be investigated. The results of the directivity measurements obtained from QinetiQ suggest a uniform sound distribution although they are not completely symmetrical. Therefore, QinetiQ flat panel speakers are modelled as both point sources and surface sources to compare the results.

2.1 Modelling as a point source

The modelling of the flat panel speaker as a point source is done based on the directivity data provided by QinetiQ. The easiest way to enter a new directivity plot is to use the built-in plot editor in ODEON. This allows building a directivity plot from vertical and horizontal plots. The ODEON directivity pattern file contains information on the sound levels for the eight frequency bands (from 63Hz to 8 kHz) for each 10 azimuth and 10 elevation. The measurements done by QinetiQ provided a 30 degrees angular resolution. Since the data for each 10 degree is not available ODEON does the interpolation between the angles entered.

2.2 Modelling as a surface source

The surface source is intended for modelling structures such as the body of a vibrating machine, where the sound energy can be assumed to be radiated diffusely from an infinite number of points on the surface source.

Surface sources are based on the surfaces defined in the room geometry. Therefore, surfaces (180x25cm) which are representatives of QinetiQ flat panel speakers are physically modelled in ODEON. These surfaces are selected and “source data” is applied to them. The source data determines the output level.

3 SIMULATIONS WITHOUT ABSORPTION

3.1 Simulation Set-up

Four simulation set-ups were used in the metro station modelling to compare the results. One of the platforms in the station is selected to be used for the simulations. The simulations were as follows:

1. Traditional column speakers facing down platforms
2. Traditional column speakers facing towards track
3. QinetiQ flat panel speakers modelled as point sources
4. QinetiQ flat panel speakers modelled as surface sources

The acoustical power and the directivity of the traditional column speakers were measured and applied in the ODEON model. The directivity of the column speaker is defined in common loudspeaker format to be used in ODEON and therefore, this directivity is used in our simulations.

In the first simulation, the traditional loudspeakers are placed in every 4 meters in the platform. In all four simulations the same speaker positions are used. (In total 23 speakers) In the second simulation, column speakers are faced towards the track. The third and fourth simulations are the two different modelling of the flat panel speakers; one as a point source and the other as a surface source as described in Section 2.

3.2 Input sound pressure levels

Approximately L_{Aeq} of 81 dB(A) in the platform is used for as the background noise in ODEON. (which is a worst case scenario) Table 1 displays the frequency response of the background noise levels used as in input in ODEON.

Table 1: The background noise frequency response

Freq.	125	250	500	1000	2000	4000	8000	dB(A)
	82	83	79	74	72	68	57	80.9

The simulations are done for the emergency situation. Therefore, the sound pressure levels were calibrated such that an average of 90dB (A) L_{Aeq} across the platforms is achieved. Therefore, the STI levels are expected to be lower due to low S/N ratio.

An average STI value of 0.5 is assumed to be an appropriate value for good intelligibility in this platform. However, the coverage across the platform is necessary to take into account. Therefore, 'Average STI-standard deviation' value of 0.43 is assumed to be a better indicator of speech intelligibility across the platform.

3.3 Results

The results of the simulations were examined in graphical form as STI grid plots and total SPL(A) grid plots and as cumulative distribution graphs for STI and SPL(A). However, for practicality reasons only cumulative distribution graphs are shown in this paper. Figure 1, Figure 2, Figure 3 and Figure 4 demonstrate the cumulative distribution of STI for four simulations in the platform. Figure 5 gives a summary of the STI results.

Results suggest that ODEON performs SLIGHTLY better when QinetiQ flat panel speakers are modelled as surface sources. The STI results are comparable with little difference between column and panel speakers. (The panels perform better in the order 0.05 in STI values) However, the cumulative distribution graphs demonstrate that coverage across the platform is better by panel speakers. (Especially when modelled as surface sources) compared to column speakers.

The STI results are still below the average STI value of 0.5 and 'Average STI-standard deviation' is below 0.43.This is mainly due to the high background noise levels and reflective surfaces in the platform. All these simulations are done when the platforms comprise of reflective surfaces. The results are believed to improve in the existence of absorption in the platforms.

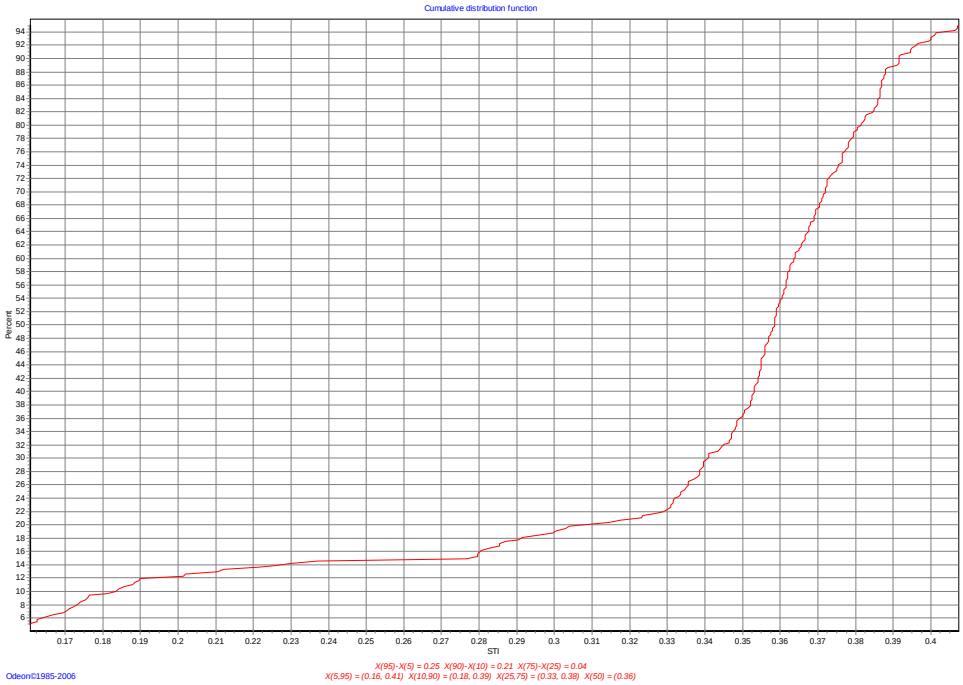

Figure 1: Cumulative Distribution - STI Column Speakers (facing towards down platform)

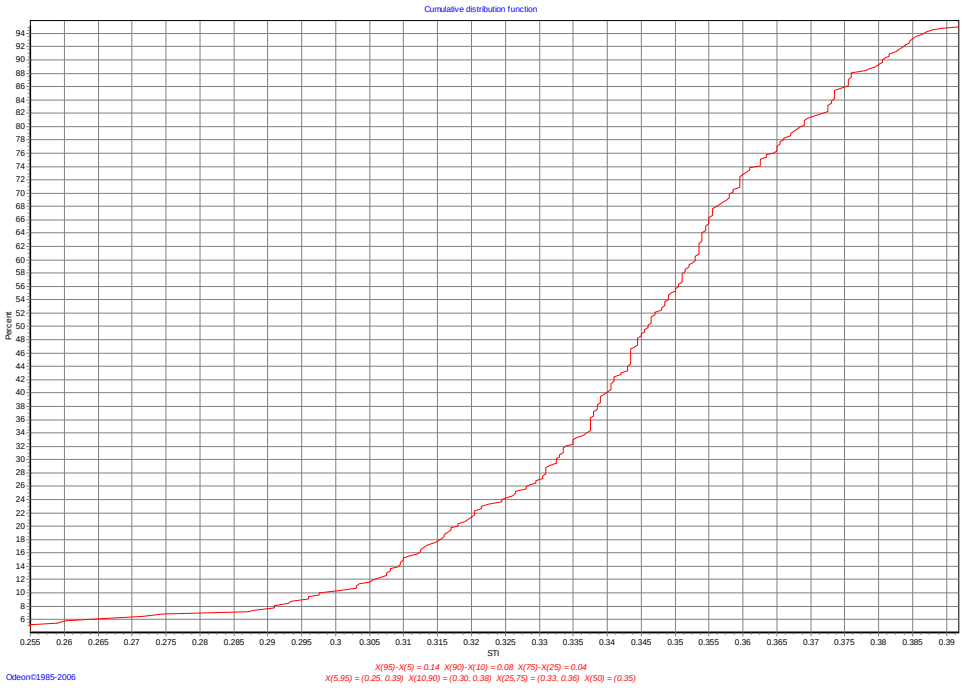

Figure2: Cumulative Distribution - STI Column Speakers (facing towards track)

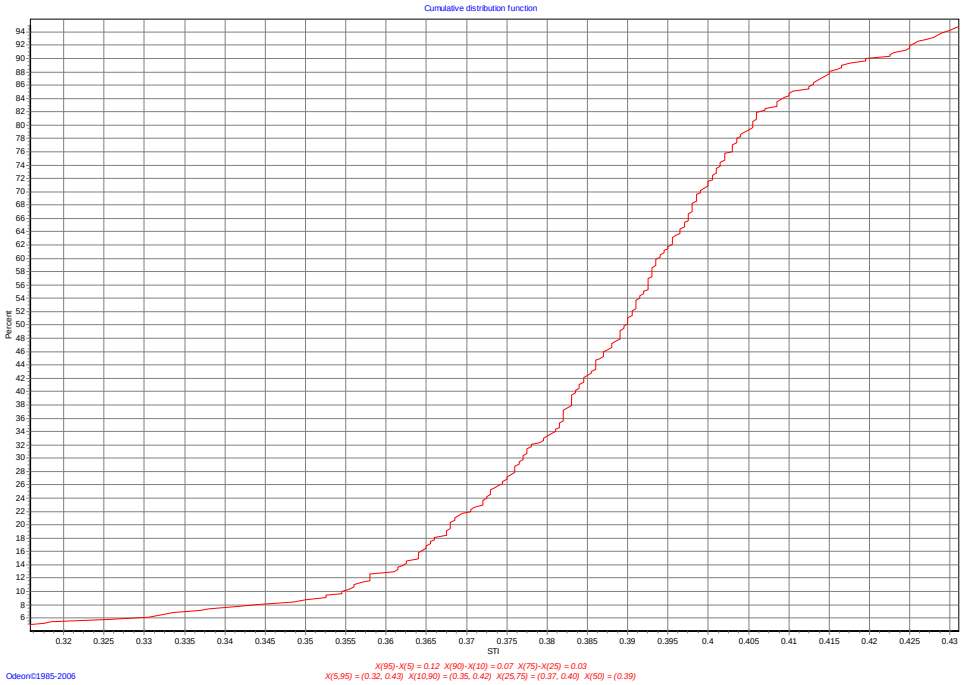

Figure 3: Cumulative Distribution - STI QinetiQ Panel Loudspeakers (Point Sources)

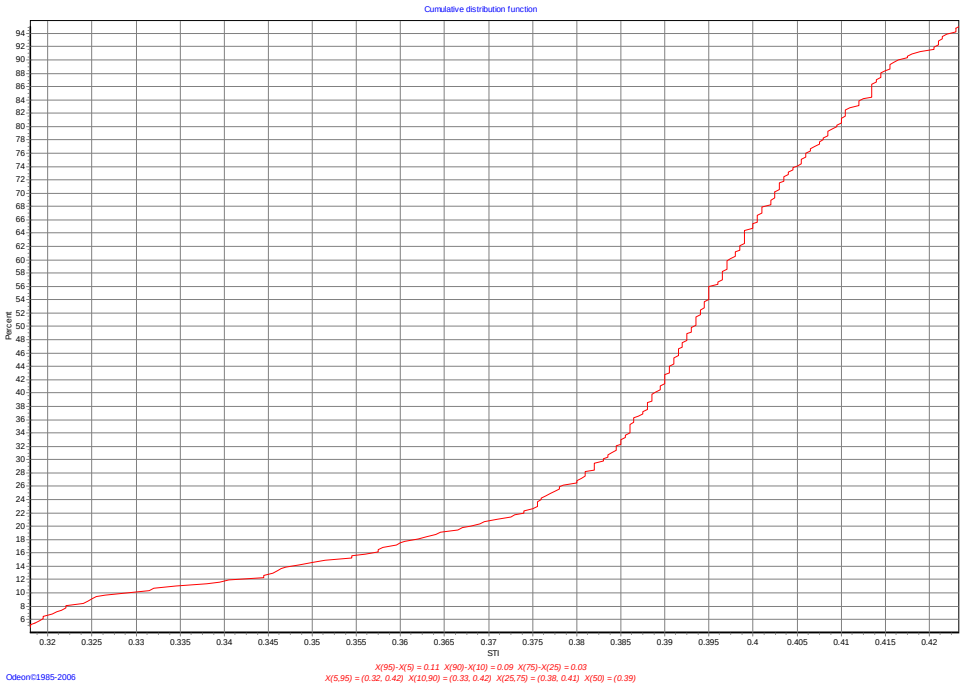

Figure 4: Cumulative Distribution - STI QinetiQ Panel Loudspeakers (Surface Sources)

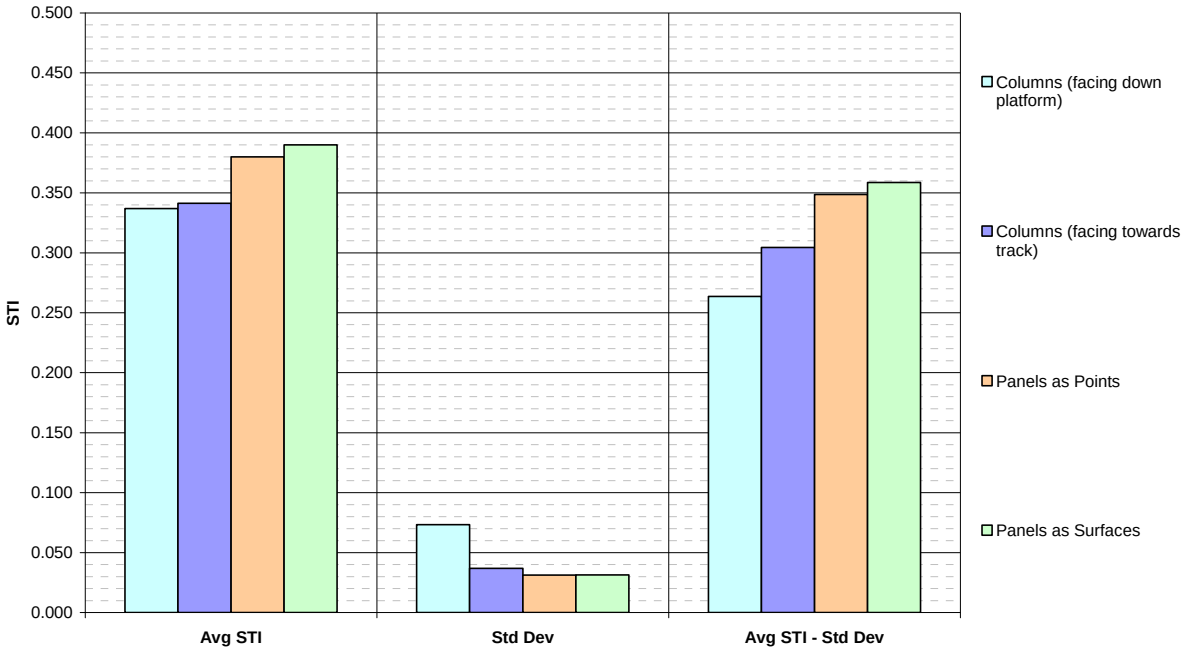

Figure 5: STI summary results

4 SIMULATIONS WITH ABSORPTION

The results of the previous simulations indicate that the average STI results are below 0.5 and 'Average STI-standard deviation' results are below 0.43 both by traditional speakers and flat panel speakers. New simulations are done to find the amount of absorption to be used in the platform to reach 'Average STI-standard deviation' of 0.43 by traditional column speakers and flat panel speakers. The same set-up from the previous section is used in the simulations. Absorption is introduced as ceiling treatment. Table 2 shows the absorption coefficients of the acoustic treatment applied on the ceiling.

Table 2: The absorption coefficients of acoustic treatment applied on the ceiling.

Ceiling	Generic	63	125	250	500	1000	2000	4000	8000
		0.40	0.40	0.80	0.90	0.85	0.75	0.55	0.50

Several simulations with different amount of absorption are run until the 'Average STI-standard deviation' of 0.43 is achieved by column speakers and panel speakers. In each simulation the SPL should be calibrated again since the addition of absorption causes the SPL to drop.

The results demonstrate that that ‘Average STI -standard deviation’ value of 0.43 is achieved by panel speakers when ~ **135m^2** of absorption on the ceiling is applied. However, to reach the same value **~ 280m^2** of absorption on the ceiling is necessary with column speakers.

The results of STI cumulative distribution graphs for column speakers with the necessary amount of absorption to reach ‘Average STI -standard deviation’ value of 0.43 are shown in Figure 6 and Figure 7.

The results of STI cumulative distribution graphs for panel speakers with the necessary amount of absorption to reach ‘Average STI -standard deviation’ value of 0.43 are shown in Figure 8 and Figure 9.

Figure 10 gives a summary of STI results for column speakers. Figure 11 gives a summary of STI results for panel speakers

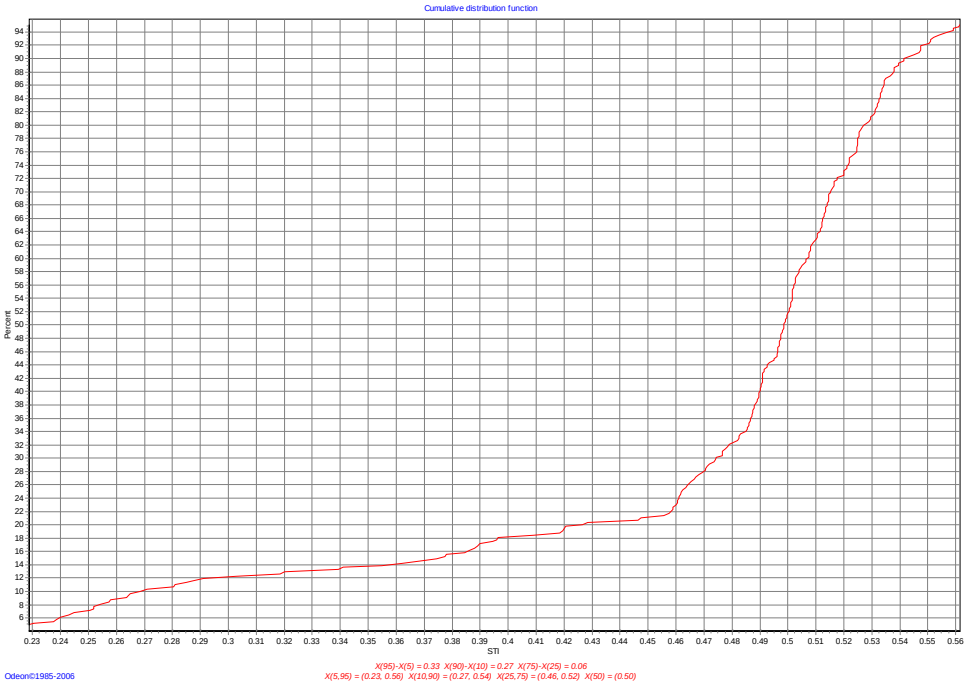

Figure 6: Cumulative Distribution – STI Column Speakers (facing down platform) with 278m^2 absorption

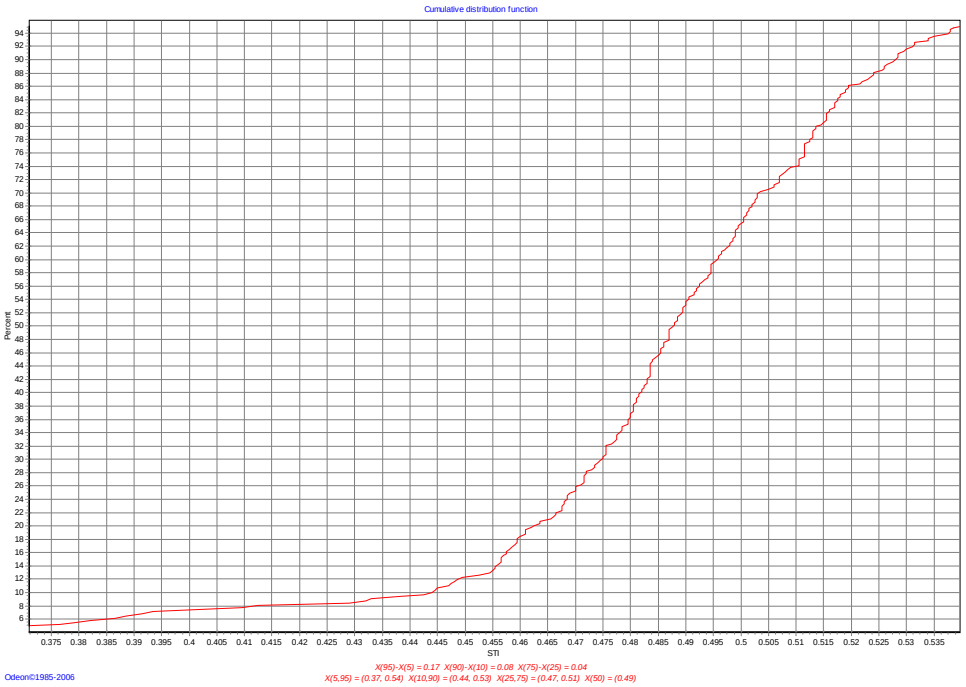

Figure 7 - Cumulative distribution– STI Column Speakers (facing towards track) with 278m^2 absorption

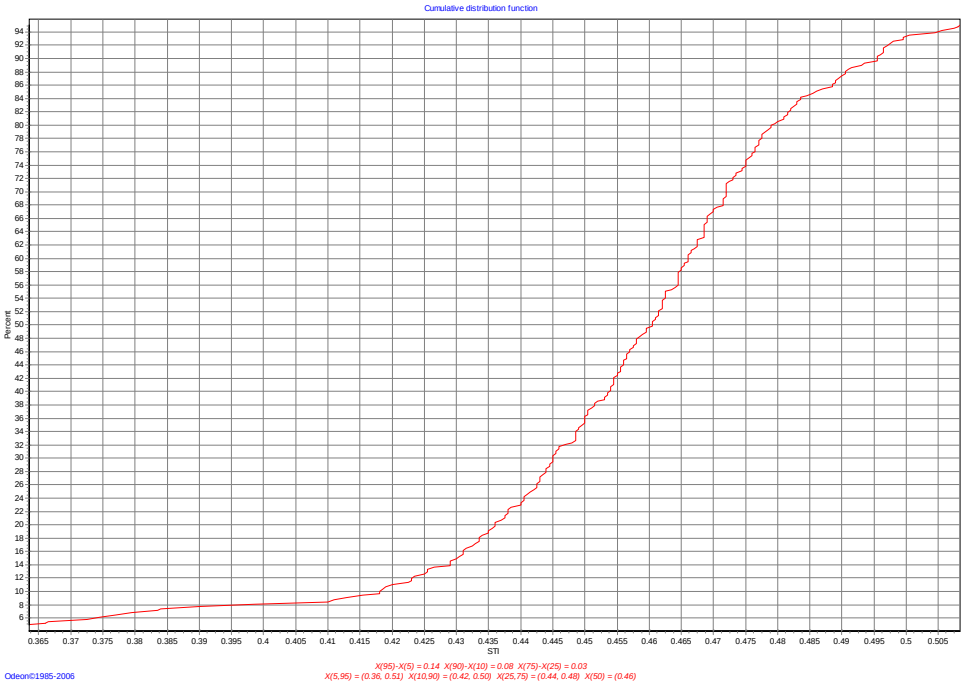

Figure 8: Cumulative Distribution - STI QinetiQ Panel Loudspeakers (Point Sources) with 135m^2 absorption

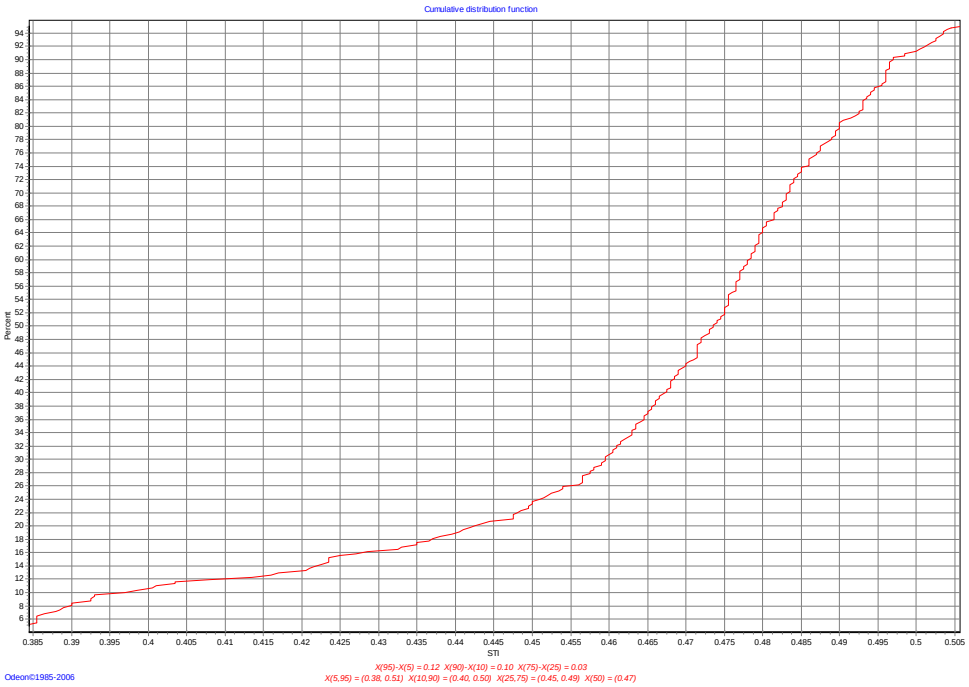

Figure 9: Cumulative Distribution - STI QinetiQ Panel Loudspeakers (Panel Sources) with 135m^2 absorption

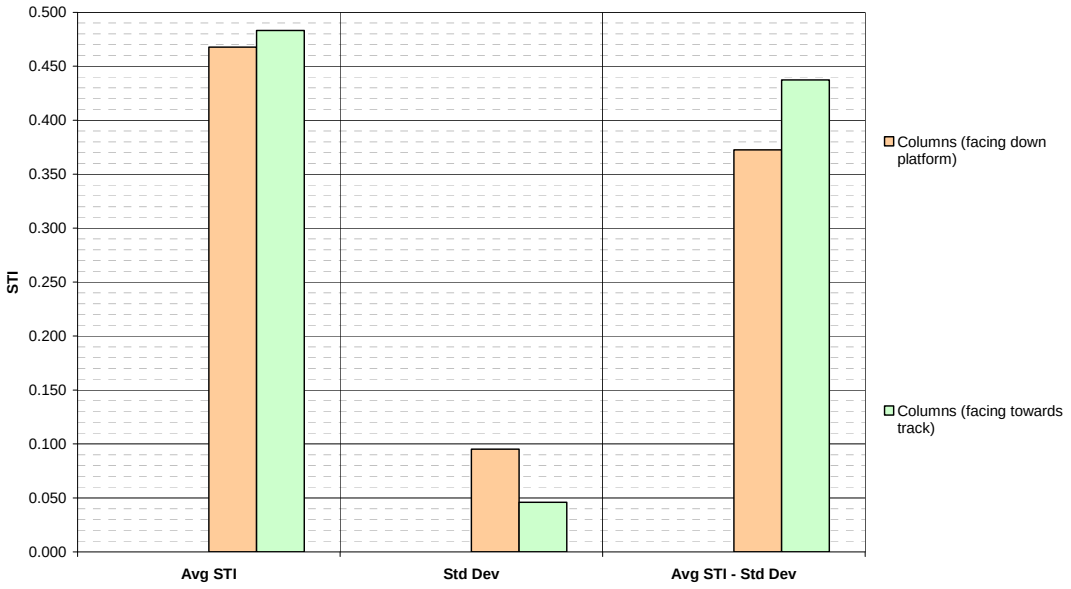

Figure 10: STI Summary Results for column speakers with 278m^2 absorption

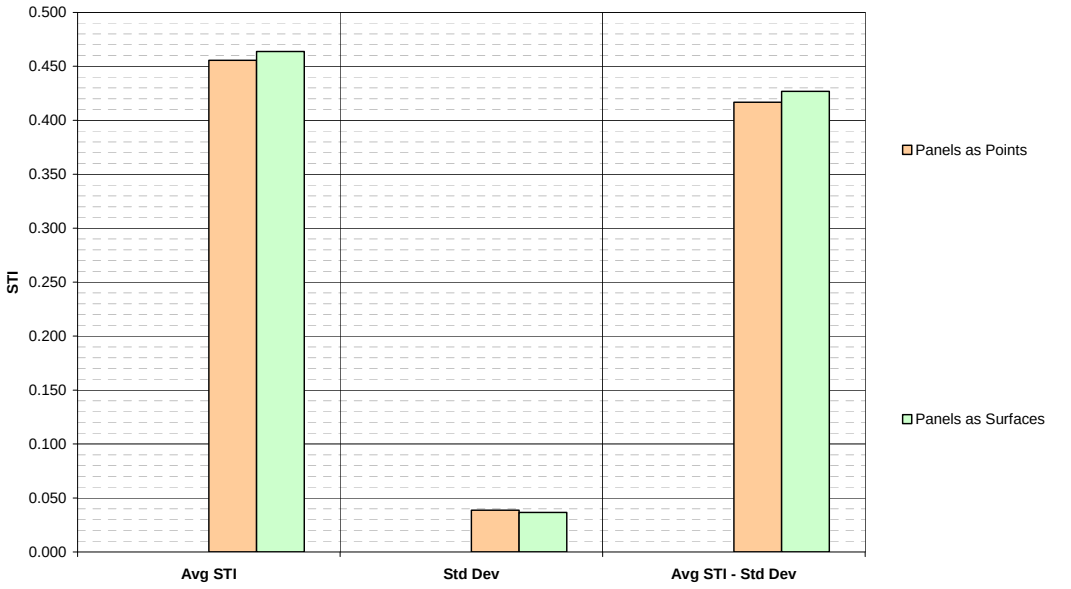

Figure 11: STI Summary Results for panel speakers with 135m2 absorption

5 CONCLUSIONS

Results suggest that ODEON performs SLIGHTLY better when flat panel speakers are modelled as surface sources if there is no acoustic treatment in the platform. The STI results are comparable with little difference between column and panel speakers. However, the cumulative distribution graphs demonstrate that coverage across the platform is better by panel speakers (especially when modelled as surface sources) compared to column speakers. The STI results are below the average STI value of 0.5 and 'Average STI-standard deviation' is below 0.43

All these simulations are done when the platforms comprise of reflective surfaces. Second set-up of simulations are run to determine the amount of absorption necessary to reach 'average STI - standard deviation' value of 0.43 by column speakers and flat panel speakers. The results demonstrate that that 'Average STI -standard deviation' value of 0.43 is achieved by panel speakers when ~ **135m^2** of absorption on the ceiling is applied. However, to reach the same value **~ 280m^2** of absorption (which is double of the amount necessary by panel speakers) on the ceiling is necessary with column speakers.

The required 'Average STI -standard deviation' value of 0.43 is also only achieved when the column speakers are facing towards track and when 280 m^2 of absorption is applied on the ceiling.

Panel speakers provide a better coverage on the platform, therefore, with less absorption 'Average STI -standard deviation' value of 0.43 could be reached.