Sanctuary Acoustic Response Study

For

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Presented By Jim Murphy

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TRINITY EVANGELICAL LUTHERAN CHURCH

Sanctuary Acoustic Investigations Report

Introduction:

The Sanctuary in Northminster Presbyterian Church is beautifully designed building with traditional European architecture. The church is currently providing parishioners with a traditional worship service and a contemporary worship service. This document will present the results of a scientific research into the behavior of sound in this particular room. The results will be used to recommend the proper speakers and related equipment needed to provide a reasonable similar sound to every seat in the room. This study was undertaken as a part of a system design process and is not exhaustive but rather informative for the purposes spelled out in the Scope of Work below.

This room behaves very well as designed and should not need any additional treatment to control acoustic characteristics. Padded pews are recommended and a full covering of carpet can be maintained. System design specifics will be presented in a separate system proposal document.

Scope of Work:

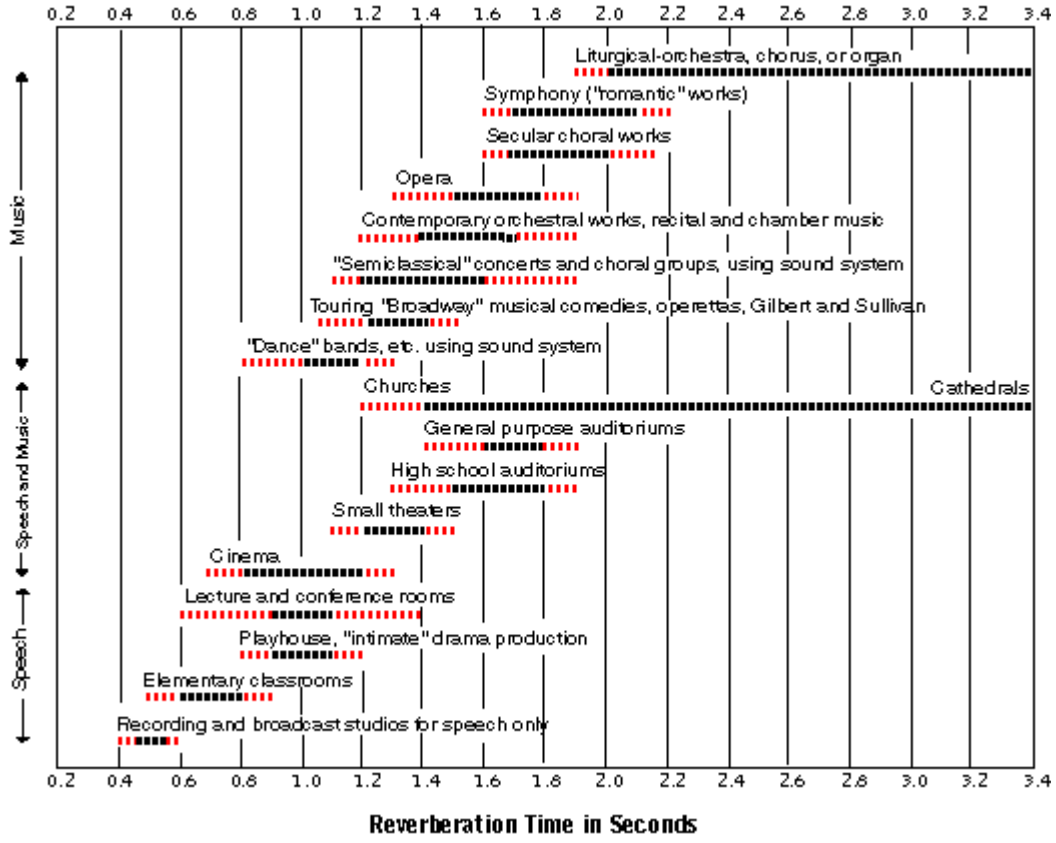
This research endeavors to study the acoustical state of the room at present and propose some modifications which might improve the intelligibility of spoken word. Statistics, charts and renderings of the various studies undertaken are presented.

Method of Study:

The primary resource for the statistics, chart and renderings in this study is the software program “Enhanced Acoustic Simulator for Engineers” (EASE). This software is the leading acoustic research and probing software developed by Dr. Wolfgang Ahnert of ADA (Acoustical Design Ahnert), Berlin. See Reference 1 to view a wireframe drawing of the room from which all calculations and renderings are made. Additional resource information was used and the references are included in the bibliography. The project started by creating a computerized model of the interior of the room including all surfaces. After completion of the design phase investigations began. The initial investigations determined the key statistics of the room in its present state. The next set of investigations included changing the surface materials at certain locations and retaking the statistics to determine the impact of the alteration to the listening environment. The last phase of the investigations included simulating the room being used with the sound system turned on and employing several variations of speaker placement. The results are presented hereafter.

The Investigations:

Over the centuries many differing studies have been done to determine what factors impact intelligibility in a room and what factors change as the room size and shape changes. From this research several measurement formulas have come to be generally accepted as presenting measurements that closely resemble the actual results in a real room. A number of studies were completed using formulas from different schools of thought. C7, C50 and C80 results are not included in the references, even though they were performed, since the results indicate the same conclusions. Therefore three tests methods were used and are included. The first of these studies is based upon the measurement of reverberation in a room or the continuation of sound in a space after the original sound has stopped. Reverberation measurements are generally noted as RT60, which is a determination of how long it takes a sound in a room to decay by 60db after the original sound has ceased. There are certain "standards" that have come into acceptance for these measurements as they relate to a particular space and dependant upon its use. Below is a list of the most common:



Graph Source: "Mechanical and Electrical Equipment for Buildings" (Fifth Edition)
Also see Reference sheets 1 and 2 for additional information.

Following is a table indicating acceptable RT60 times and acceptable uses considered from a different perspective.

RT60 s = seconds	**Results/applications**
< 1 s	Excellent intelligibility should be obtained
1.0 s – 1.2 s	Excellent to good intelligibility should be achieved
1.2 s – 1.5 s	Good intelligibility should be obtained though
> 1.5 s	Careful design required (loudspeaker design and
1.7 s	Limit for good intelligibility in large spaces
> 1.7 s	Directional loudspeaker required. Churches, multi-
> 2.0 s	Very careful design required. High quality direc-
> 2.5 s	Intelligibility will have limitations. Highly direc-
> 4 s	Very large churches, cathedrals, mosques, large and

From "Handbook For Engineers" 3rd Ed. Glen M. Balou editor pg. 1261

See Reference 2 and Reference 3 for additional resources on reverberation.

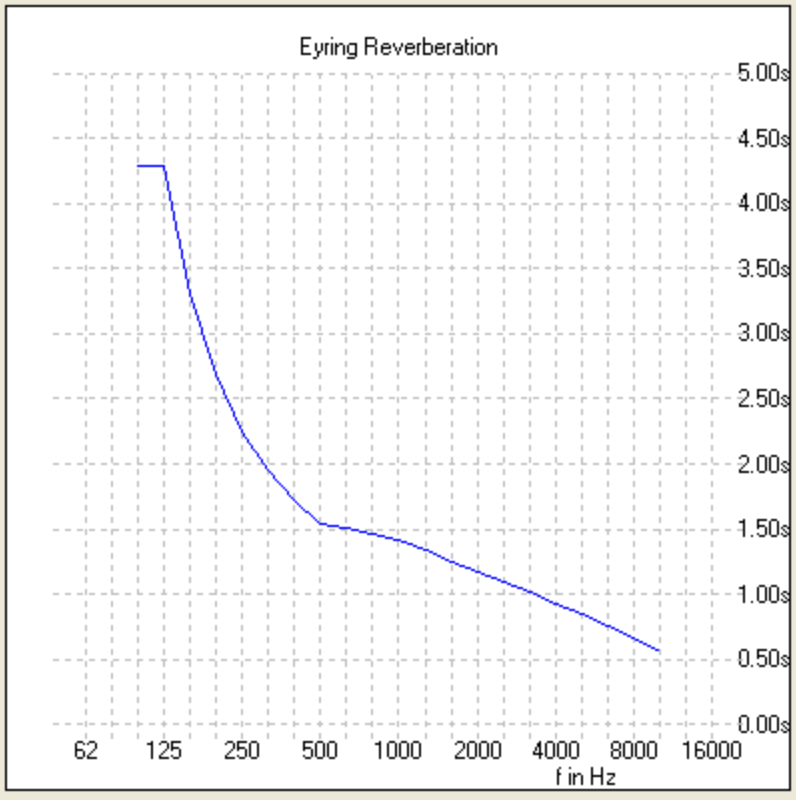
It is generally considered that the acceptable range for spoken word is from .75 – 1.5 seconds. For this standard the frequency range of 500 to 1000 is used either as a selected frequency or an average of the measurements within this
range. Audience size is also considered in this evaluation and an effort to hold the RT60 within this range in a full room is also made. For our investigations I have chosen to use an average measurement incorporating the 4 frequencies of 500Hz, 630Hz, 800Hz and 1000Hz averaged. The target maximum is between 1 and 1.5 seconds with the room partially full of parishioners.

TR-60 Measurements

Project

Hall :	Sanctuary	Town :	EASE Town
Version :		RT desired :	0 s

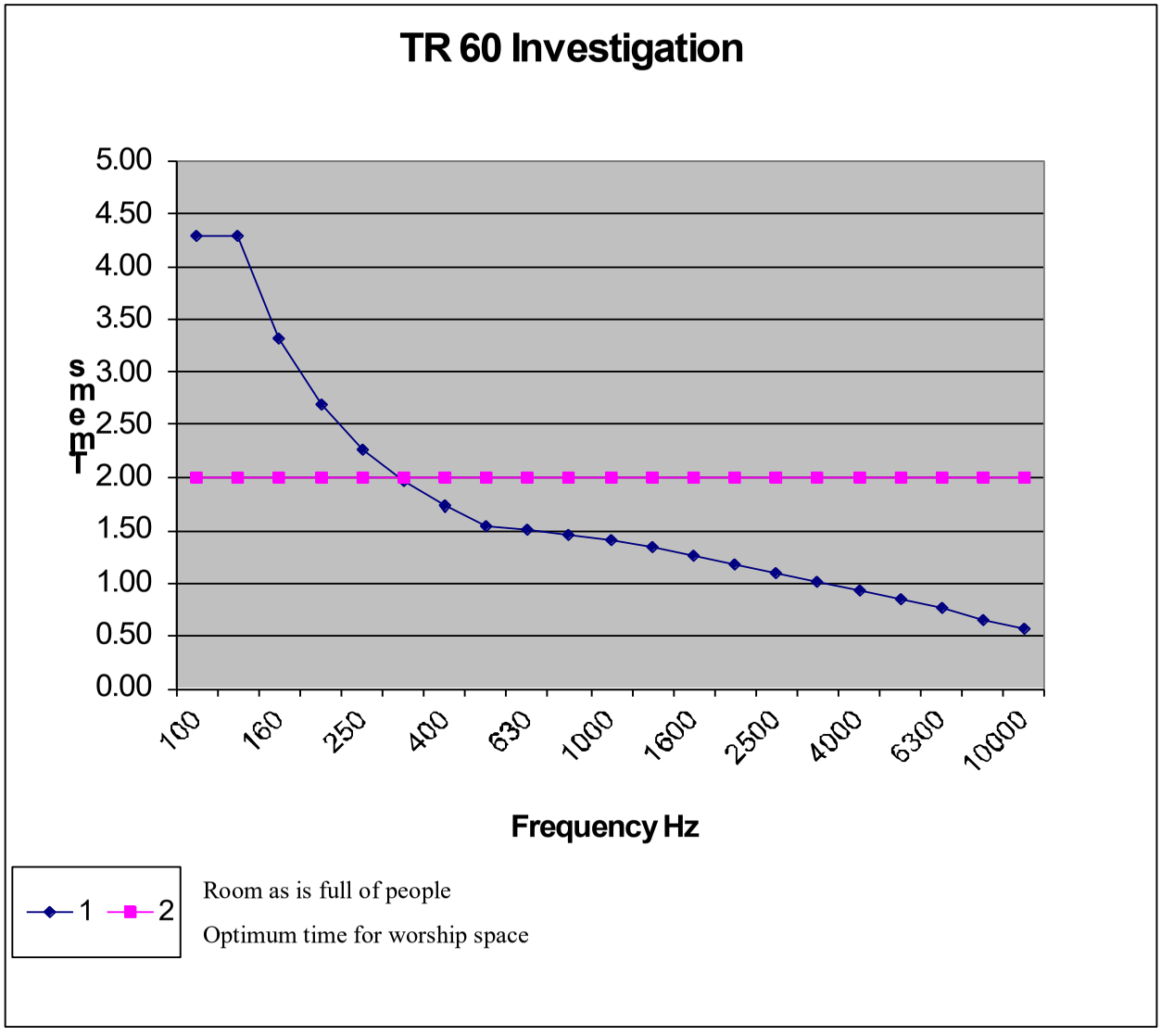
Geometry		Absorption		Mean Free Path	
Room Surface :	11347.23 ft²	Avg. Abs. Area :	1929.24 ft²	Length :	21.59 ft
Volume :	61246.46 cu.ft	Avg. Abs. Coeff. :	0.17	Time :	0.01 s



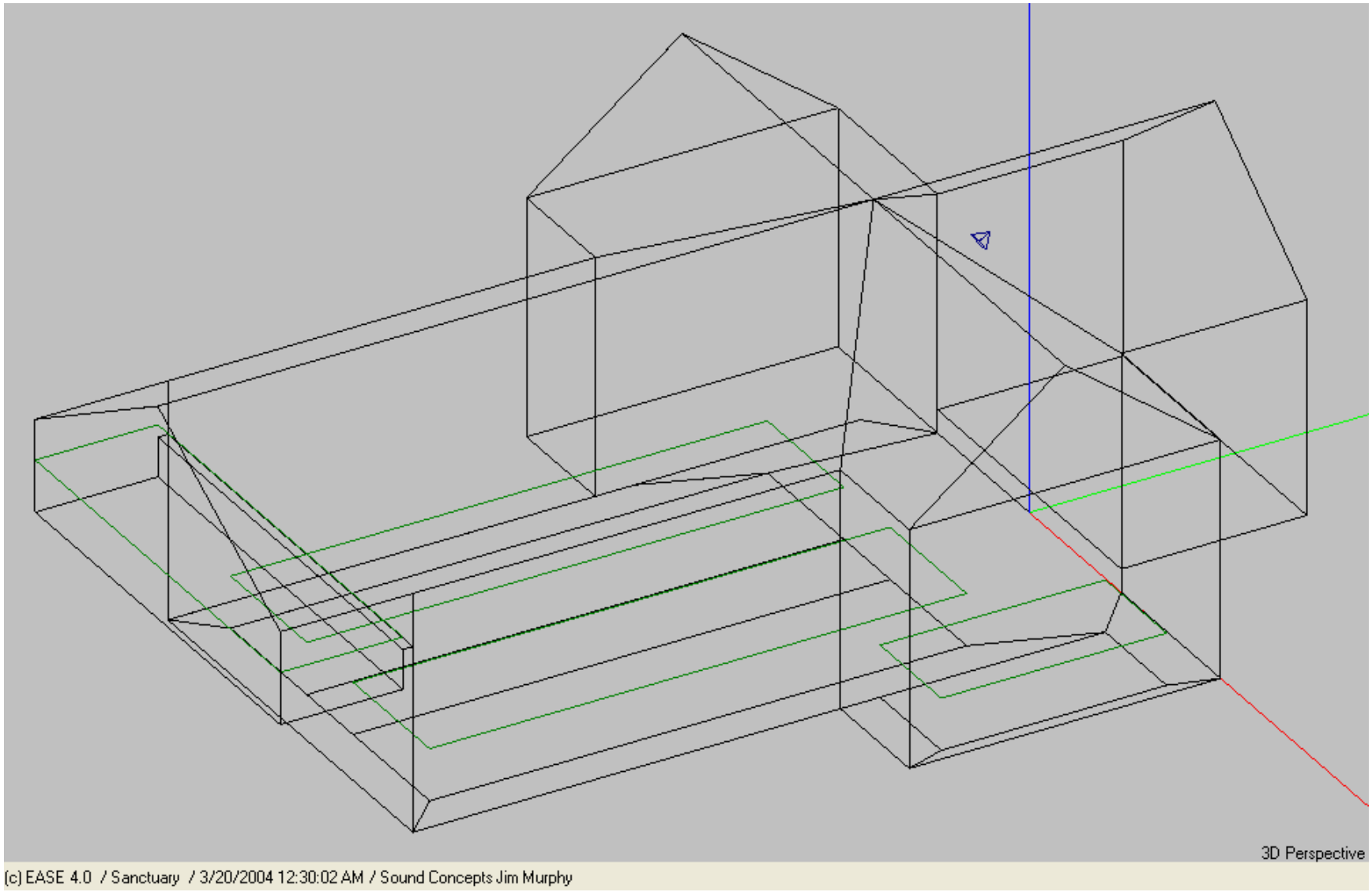
Band	RTime [s]
100 Hz	4.29
125 Hz	4.29
160 Hz	3.31
200 Hz	2.69
250 Hz	2.25
315 Hz	1.96
400 Hz	1.73
500 Hz	1.55
630 Hz	1.51
800 Hz	1.46
1000 Hz	1.42
1250 Hz	1.34
1600 Hz	1.26
2000 Hz	1.18
2500 Hz	1.1
3150 Hz	1.02
4000 Hz	0.93
5000 Hz	0.86
6300 Hz	0.77
8000 Hz	0.66
10000 Hz	0.57

(c) EASE 4.0 / Sanctuary / 3/22/2004 9:15:40 AM / Sound Concepts Jim Murphy

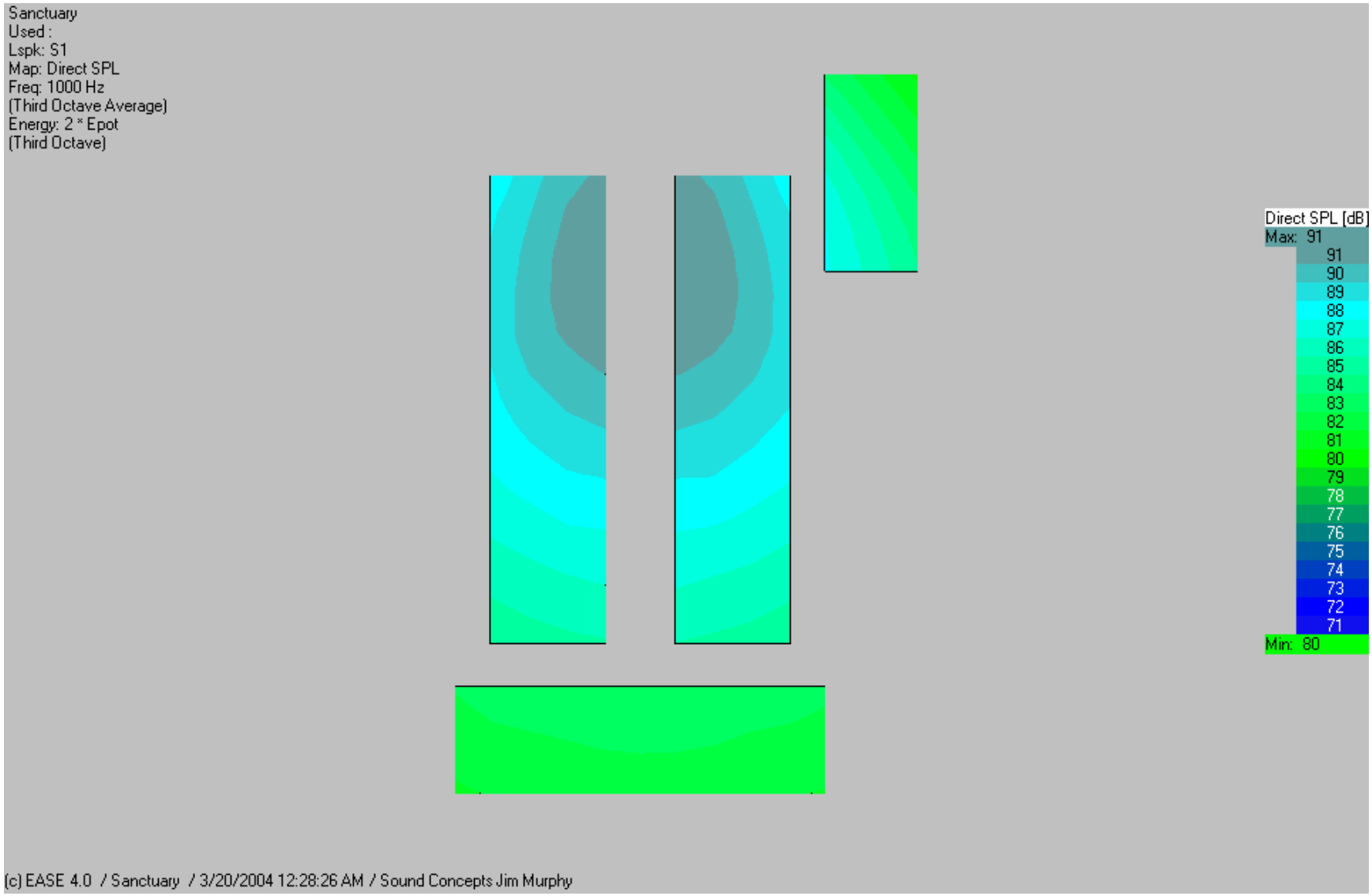
RT60 chart measured with the room full of people. Optimal target time for a room of this type is 2 seconds.



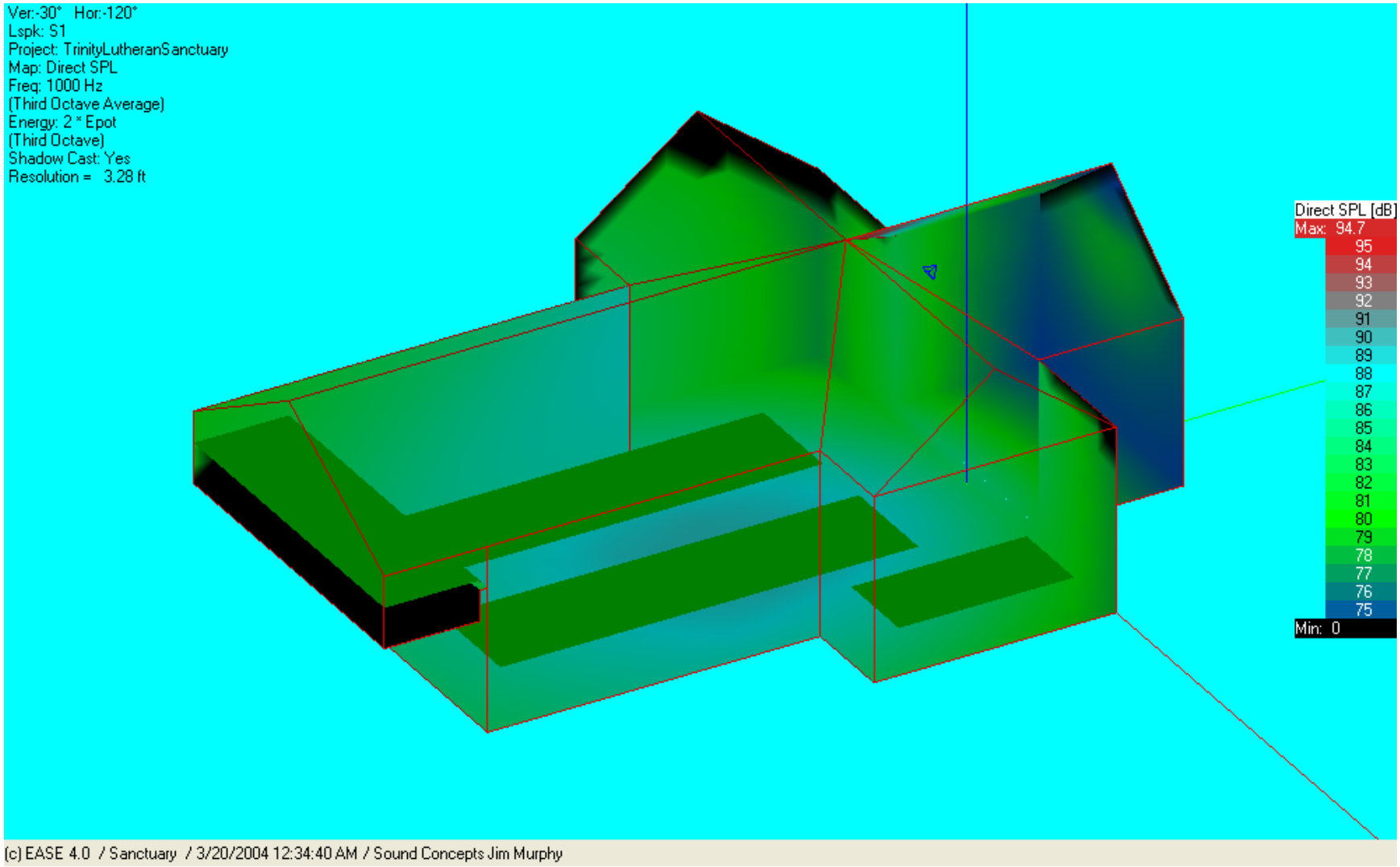
Trinity Lutheran Church
Ease Results



Trinity Lutheran Church
Ease Results
TRX121T/6 FOH only



Trinity Lutheran Church
Ease Results
TRX121T/6 FOH only



Trinity Lutheran Church
Ease Results Audience Areas
TRX121T/6 FOH; TRX81 Side Fill; TX62 Balcony