



Room Acoustic Evaluation of Small Rooms

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1. Introduction

- ▶ Broadcasting studios, control rooms and listening rooms are usually small rooms
- ▶ **The aim:** to find new parameters for small rooms, which correspond to the subjective side
- ▶ **The demand:** using the new objective parameters in acoustic design and in an acoustic modeling software



*...to predict the acoustical
quality of the sound field
in the room.*

2. Concept

- ▶ **The need:** to test the different techniques and sound recordings by listening tests, calls for improvement of listening environments



...investigation of the listening and control rooms

- ▶ **Method:** similar to the method for concert halls
- ▶ **Task:** to find and extract the important factors more precisely describing the acoustical behavior of a room



to define a set of
subjective parameters

to find corresponding
objective parameters

3. General Considerations

Two general test methods:

1. Subjects are in a **synthetic sound field** created by means of electroacoustic equipment in anechoic rooms
2. Subjective tests are in several rooms

Advantages and disadvantages

	simulated sound fields	real rooms
sound field	▼ simplified and unnatural	▲ realistic
variation	▲ within very wide ranges	▼ limited
electroacoustic techn.	▲ same	▼ different

In our work: investigations in real rooms

- ▲ 7 listening and control rooms

4. Method of Subjective Investigations

- ▶ **Subjects:** experts and students - *ear training*
- ▶ **Demo records:** selection of the records together with the subjects. 40 minutes long demo was recorded.
- ▶ **Questionnaire:** it is difficult to characterize the acoustic “quality” - *vocabulary* which can describe the acoustic experiences in the room
- ▶ During a test there are three subjects present at the same time

4. Method of Subjective Investigations

Listening Test

Name:	Room:	<i>Magyar Rádió</i> <i>RTO</i>
Date:	Test material:	
Number of listening position:		

Value must lie within 1 and 6: 1 means the worst, 6 means the best verdict.

	FEATURE	MARK	REMARK
1.	Stereo accuracy		
2.	Spatial impression		
3.	Transparency		
4.	Timbre		
5.	Frequency response		
6.	Room resonance		
7.	Position dependence		
8.	Other resonance (e.g. equipment)		
9.	Noise from equipment and outside		
10.	Main impression		
11.	Comfort		

5. Interpretation of results

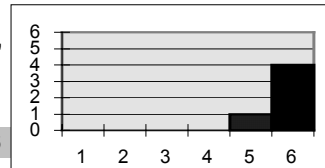
▶ (example "good")

Control Room No. 22

1 Stereo accuracy

"1"	"2"	"3"	"4"	"5"	"6"
0	0	0	0	1	4

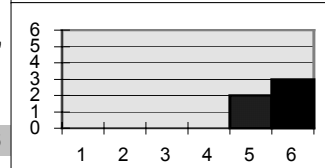
median: **6**



2 Spatial impression

"1"	"2"	"3"	"4"	"5"	"6"
0	0	0	0	2	3

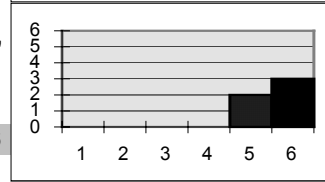
median: **6**



3 Transparency

"1"	"2"	"3"	"4"	"5"	"6"
0	0	0	0	2	3

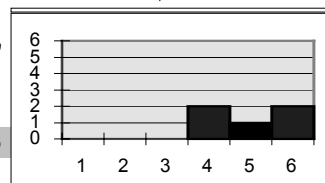
median: **6**



10 Main impression

"1"	"2"	"3"	"4"	"5"	"6"
0	0	0	2	1	2

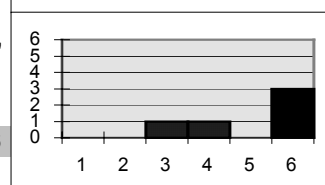
median: **5**



11 Comfort

"1"	"2"	"3"	"4"	"5"	"6"
0	0	1	1	0	3

median: **6**



5. Interpretation of results

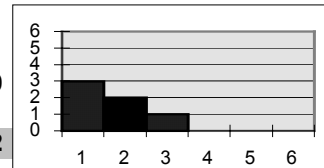
▶ (example "poor")

Listening room of the Musical Director

1 Stereo accuracy

"1" "2" "3" "4" "5" "6"
 3 2 1 0 0 0

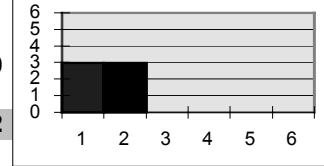
median: **2**



2 Spatial impression

"1" "2" "3" "4" "5" "6"
 3 3 0 0 0

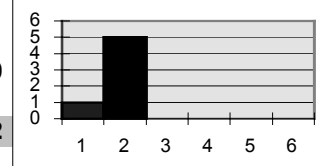
median: **2**



3 Transparency

"1" "2" "3" "4" "5" "6"
 1 5 0 0 0

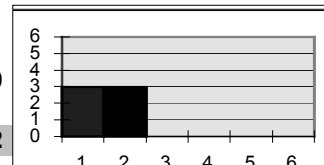
median: **2**



10 Main impresson

"1" "2" "3" "4" "5" "6"
 3 3 0 0 0

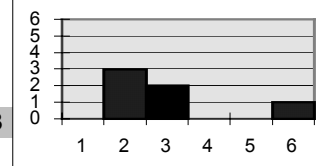
median: **2**



11 Comfort

"1" "2" "3" "4" "5" "6"
 0 3 2 0 0 1

median: **3**



6. Objective Parameters

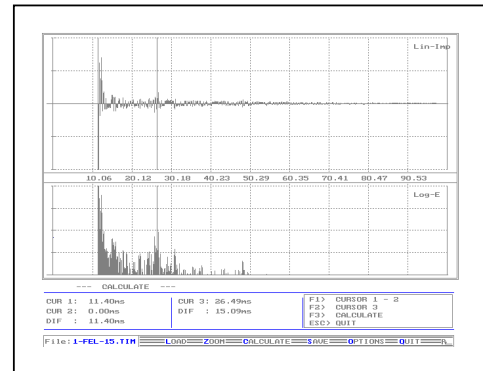
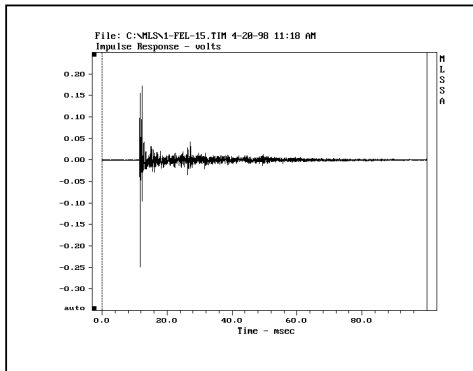
- ▶ Linear transmission of sound between source and receiver is fully described by the IR.
- ▶ But the IR is too detailed in which it is difficult to distinguish between important and irrelevant properties
- ▶ **Measurements...**

The acoustical measurements were carried out by using MLSSA analyzer of DRA Laboratories.
- ▶ **Sound field parameters** (specified by the EBU)
 - ◆ direct sound
 - ◆ early reflections
 - ◆ reverberant field
 - ◆ operational room response curve
 - ◆ background noise
- ▶ **Experiences:** new parameters are needed

6. Objective parameters

► Calculated parameters...

A new evaluation program has been created



■ M-factor:

$$M = k_2^{[dB]}(20 \text{ ms}) - k_2^{[dB]}(5 \text{ ms})$$

$$k_1(t) = 10 \cdot \log_{10} \frac{\int_0^t p^2(t) dt}{\int_0^\infty p^2(t) dt} \quad \text{and} \quad k_2(t) = 10 \cdot \log_{10} \frac{\int_t^\infty p^2(t) dt}{\int_0^\infty p^2(t) dt}$$

■ Center time:

$$t_s = \frac{\int_0^\infty p^2(t) dt}{p_{\max}^2}$$

6. Objective parameters

► Calculated values

15 ms	t_s [ms]		$k_{1(15ms)}$ [dB]		$k_{2(15ms)}$ [dB]		$M_{(15ms)}$ [dB]	
	Left	Right	Left	Right	Left	Right	Left	Right
St 1	10.46	10.53	-0.3	-0.328	11.53	11.06	0.401	0.378
St 6	18.93	16.69	-0.926	-0.749	6.24	7.26	0.232	0.279
St 8	17.32	20.9	-0.569	-0.605	8.54	8.26	0.124	0.103
St 22	12.09	12.98	-0.428	-0.418	9.85	9.95	0.126	0.172
St 23	10.59	11.4	-0.286	-0.344	11.67	10.83	0.145	0.129
LR 24	9.1	10.17	-0.179	-0.298	13.75	11.49	0.105	0.091

20 ms	$k_{1(20ms)}$ [dB]		$k_{2(20ms)}$ [dB]		$M_{(20ms)}$ [dB]	
	Left	Right	Left	Right	Left	Right
St 1	-0.233	-0.254	12.6	12.2	0.507	0.493
St 6	-0.8	-0.606	6.94	8.24	0.302	0.378
St 8	-0.473	-0.564	9.39	8.58	0.209	0.135
St 22	-0.288	-0.314	11.63	11.25	0.305	0.302
St 23	-0.26	-0.281	12.09	11.75	0.188	0.221
LR 24	-0.168	-0.283	14.03	11.72	0.133	0.114
LR Dir	-0.775	-1.014	7.09	5.08	0.468	0.507

7. Subjective vs. Objective

Specified parameters:

- ▶ Direct sound - loudspeaker parameters
 - ◆ In studio-technique: usually the loudspeakers suit the recommendation.
 - ◆ *Stereo accuracy, spatial impression, transparency, timbre, frequency response, noise, main impression*
- ▶ Reverberation
 - ◆ In small rooms still “the key parameter”, but correlation is not so trivial.
 - ◆ If reverberation time is too short (<0.2 sec), working environment is tiring (*main impression*).
- ▶ Early reflections
 - ◆ Strong reflections (15-20ms) are disturbing (<-10dB relative level recommended)
 - ◆ *Stereo accuracy, spatial impression, timbre.*
- ▶ Operational room response curve
 - ◆ Subjectively a key parameter
 - ◆ *Timbre, frequency response, room resonance, position dependence*

7. Subjective vs. Objective

- ▶ Background noise
 - ◆ *Noise from equipment and outside.*

Calculated parameters

...new parameters are needed to qualify more precisely the acoustic behavior of small rooms.

Recommended values

- ▶ Clarity: k_1 and k_2 factors
 - ◆ Subjectively: *spatial impression*, *stereo accuracy*
- ▶ M-factor
 - ◆ Subjectively: *spatial impression*
- ▶ Center time (t_s)
 - ◆ Subjectively: *transparency*

8. Modeling

- ▶ Prediction of acoustical quality before the implementation
- ▶ New modeling software optimized for new parameters
- ▶ Features:
 - ◆ Beam-tracing
 - ◆ Beam split-up at diffuse reflection
 - ◆ Sampling in detection of reflections
 - ◆ Equipment and furniture are taken into account
- ▶ Automated material property calibration based on measured data

9. Conclusions

- ▶ Generally used sound field parameters can't describe subjective impression thoroughly for small rooms
- ▶ Listening tests and measurements were carried out
- ▶ Recommended new parameters are:
 - ◆ modified M-factor
 - ◆ energy-time integrals (k_1, k_2) with different split points
 - ◆ center time t_s
- ▶ Modeling of small rooms is a special challenge
 - ◆ special materials
 - ◆ small sizes
 - ◆ furniture and equipment effect the sound field
- ▶ Main errors of modeling induced by uncertain material description libraries...