



METHODS OF CHOIR RECORDING FOR AN AUDIO ENGINEER

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<p>Summary:</p> <p>This thesis is about finding out what a recording engineer needs to know before starting to record a choir recording, in order to make it well. A good choir recording is very hard to determine, because there is not a one and only perfect way how to do one. That is why I have collected some good advice and different opinions here, and aspects of how to make a good recording, so that everyone involved are happy with the results, not only the makers of the record, but the audience and the critics as well.</p> <p>The success and making the record good is not only on the shoulders of a recording engineer. The quality is pretty much dependent on everyone involved with the recording, for example the producer, the audio engineer, possible mastering engineer, the choir director and of course the actual choir. By far, the most important thing concerning quality is of course the acoustics that dominates the entire recording.</p> <p>This thesis is compiled from interviews, articles and books of the people who work on the industry, and have been making choir recordings. It is a comparison between my own knowledge and experience to other professionals working on the industry.</p>	
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<p>Tiivistelmä:</p> <p>Tässä opinnäytetyössä otan selvää mitä äänittäjän täytyy tietää ennen kuoroäänitteen tekoa, jotta äänitteestä tulisi äänellisesti mahdollisimman hyvälaatuinen. On hyvin vaikeaa määrittellä millainen hyvän äänitteen pitää olla, koska sen tekemiseen ei ole vain yhtä oikeaa tapaa.</p> <p>Tarkastelen eri metodeita ja tapoja, joiden avulla toteuttaa kuoroäänitteen tekeminen sekä selvittää mitä alalla vuosia vallinneet työskentelytavat ja rutiinit ovat. Siksi olenkin koonnut paljon hyviä neuvoja ja eri mielipiteitä, jotta lukija voi itse päättää mikä hänen mielestään olisi se oikea tapa tehdä kuoroäänite. Tärkeintähän on, että kaikki äänitysprosessissa mukana olevat henkilöt ovat tyytyväisiä tulokseen ja sitä kautta yritetään saada myös kuulijakunta tyytyväiseksi.</p> <p>Paineet levyn onnistumisen suhteen eivät ole kokonaan äänittäjän harteilla, sillä laatuun vaikuttavat äänittäjän ohella myös kuoronjohtaja, taiteellinen tuottaja, mahdollinen masteroija ja tietenkin itse kuoro. Kaikista eniten äänitteen laatuun vaikuttaa kuitenkin äänityspaikan valinta ja akustiikka.</p> <p>Tämä opinnäytetyö on koottu haastatteluiden, artikkeleiden ja alan ammattilaisten kirjoittaman materiaalin pohjalta. Tarkoituksenani on vertailla omia kokemuksiani ja omaa ammattitaitoani muiden alalla työskentelevien ammattilaisten tekotapoihin ja rutiineihin.</p>	
Aineisto Audio CD	
Asiasanat Kuoro, Kuoron äänittäminen, Kuoroäänittäminen	
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1 Introduction

My purpose in this thesis is to find out what a recording engineer needs to know before starting to record a choir recording, in order to make it well. A good choir recording is very hard to determine, because there is not a one and only perfect way how to do one. That is why I have collected some good advice and different opinions here, and aspects of how to make a good recording, so that everyone involved are happy with the results, not only the makers of the record, but the audience and the critics as well. I hope that the basics of the recording techniques are already familiar to the reader to some extent.

When recording classical music you will always come across to the differences in recording techniques, and norms between different methods taught, and also between different continents. The ways of working and recording may vary a lot around the world, and common practice lies only on certain areas. Globally, the aim is of course the same; to make the best sounding recording ever. In Finland, the control of quality is maintained by the choir societies. In the west, it is possible to win even a Juno award or a Grammy with a good choir recording.

The success and making the record sound good is not only on the shoulders of a recording engineer. The quality is pretty much involved with everyone involved with the recording, for example the producer, the audio engineer, possible mastering engineer, the choir director, and of course the actual choir. The most important thing by far regarding the quality is of course the acoustics that dominates the entire recording.

How is this quality defined so that it meets the requirements, and that it meets the standards on different areas that have different norms and requirements in quality? Also, who is ready to criticize and throw doubt on the quality and level of choir recordings? What are the criteria that need to be met in the recording, and who is the person to determine those criteria? The starting point seems to be on many directions that not everyone is qualified and able to do a good choir recording without knowing the norms and methods of practice on this field of acoustic recording techniques.

This is why I am trying to find out what recording a choir requires, and how the recording engineer needs to be prepared, even if the arrangement of the actual recording situation is always different with different choirs. Not only is it good to know beforehand what equipment are needed, but it is also good to know about the different methods and norms on the actual recording situation. A recording engineer needs to take advantage of this knowledge, and also use the acoustics with the best possible way in a recording situation, so that he/she is able to hear the outcome already at the location where the recording is taking place.

This thesis is based on my own experience as an audio engineer and to the recordings with choirs that I have done. Also, I have gathered information from professionals who work in the industry, and other directions to compare with my own experiences. I am also evaluating what would be the best way to do a choir recording. My own recordings are being presented as example material, and are appended to this work as an audio-CD.

2 The Criteria for a Good Choir Recording

Of course, different people working on the recordings want different things. I have noticed this during my own recordings many times, and also the phrases, words, expressions and meanings are different from each other to different people as well.

It is hard to determine what criteria a good recording needs to meet, because there are so many criteria's to be fulfilled. Everyone have their own opinions, and impressions about what they hear on the recordings. For starters, I have gathered a few opinions about the criteria for a good choir recording in this chapter.

2.1 The Choir Director's Criteria

The choir directors are the ones who decide when the choir makes a recording. They are the leaders of the performance and they control the perfection to a certain degree. This is different with every choir director. They want the best possible performance, when it comes to technical and artistic ways in performing. They tend to hear all the mistakes and tonal balances easily from the recordings. Sometimes they might not see the entirety.

Simplicity is very important. Also the record needs to be special in some way, different. But the main thing is that there is a trustful atmosphere among the people that are working with the recording. I want to hear the choir on the recording like I hear it live, so that is why I tend to work with the same people, who I already know. The sound I hear needs to be familiar to me, and the choir needs to sound like the choir normally sounds. (Kari Turunen, a Choir Director, Interviewed 9th of April 2008.)

Normally the choir directors are very ambitious and want the record to be amazing, something new, and something that no one else has ever done before in this way. Sometimes they want the recording to sound exactly the same as they hear the choir while conducting, and this might become a problem. The timbre and stereo image that the choir singer has while singing, and the choir director has while conducting, is not the impression how it sounds like for the audience (Koivusalo, M SULASOL 5/99 II).

Every choir director has their own partialities about the sound, and the concepts of hearing. Normally it contains a semi-long reverb and church acoustics. It all depends on the songs. With fast lyrics and fast tempo the acoustics should be of course dryer. (Pekka Nikula, a Choir Director, Interviewed 15th of April 2008.)

2.2 The Producer's Criteria

The repertory should be undivided, and when it comes to drama, it should be a working entirety. I think this is a good starting point when you are striving for a great recording. I also think that the most interesting recordings are the ones that have new and unheard material, like new compositions or some kind of an element, with a new theme or a new perspective. (Titta Lampela, a Producer, Interviewed 13th of April 2008.)

A good choir recording depends on aesthetics of the music (historic period, composer, etc...). In general, we are looking for a wide stereo picture, with enough sound definition, so that you can understand the words, but not precisely enough that you could separate each voice. (Amandine Pras, a Producer and an Audio Engineer, Interviewed 16th of April 2008.)

I think that producers are really precise and accurate with the material that is being recorded, and they always think about the entirety of the recording, although they are keen on details too, when it comes to the actual performing. They are the people behind making sure that every song recorded has a take that is performed perfectly, and in that way getting also the mood into the recordings as well.

Basically, the producers take care of the things that the choir director does not notice or does not have time for, thus the producers correct their mistakes. They also see the compiled recording as an entity.

2.3 The Engineer's Criteria

The engineers tend to lack on the details in performing, because they are noticing more of the way how it sounds. The acoustics are probably the most important thing in a choir recording

for engineers. I have noticed myself forgiving the choir for their mistakes, if the recording otherwise sounds amazing. This is something that engineers should improve on, and start to hear the performance more. Also, they should make sure that the outcome will not have mistakes that the producer or the choir director have not noticed or accepted.

The voices of the choir need to be in balance except for when it comes to different voices of the sections of the choir. That means the space needs to timbre, so that you can hear the acoustics, but not so that you can not understand the lyrics. If the lyrics are not meaningful, the acoustics can come out even more. It is important to know the musical style that the choir is striving for, and obey the ideal of the timbre, and the way of a certain music style or musical era. (Ari Koivumäki, an Audio Engineer, Interviewed 4th of March 2008.)

The repertoire should be thought through well, also some kind of a theme and graphical cover of the recording is important too. There should be also a vision of the composer or arranger how the composition should be performed. The pieces should be played very well with care and in a neat way. The tuning should also be correct, and preferably you should be able to hear the joy when playing/singing.

A good acoustic environment is necessary in order to achieve a good recording. What you need for that are the engineer and the gear. For example, the positioning of the microphones will have a big influence to the outcome. Also the opinions of the producer and the choir director affect the technical result as well. (Jouko Ahera, an Audio engineer. Interviewed 12th of April 2008.)

I would really like the choir to sound even better than hearing them live. I want to bring out the emotions in the performance more, and I think most of the choir recordings are a little boring. Of course, this depends on the style, but I would like to hear something more than the choir to sing perfectly without any mistakes. If there is no feeling into it, I think the recording is boring no matter what. I even accept mistakes, because it is human, and especially if there is a take with a great feeling, but with a mistake. I choose that take rather than a take without the feeling, and without the mistake.

2.4 The Choir's Criteria

Piritta Ylipahkala, a singer from Tampereen Yliopiston Laulajat (The University Choir of Tampere), told me before I started to record their album that they want their choir to sound as

a whole. Also, they do not want to hear exactly who is singing, and what. They do not want to hear someone's voice separated from the others, even if it is a soloist.

Normally the singers in the choirs do not want to recognise their own voice from the choir too much. The singers concentrate mainly on their performance and singing techniques, more than to the sound quality issues. They want to be happy with their singing, and not have any mistakes by certain singer(s) or mistakes by the whole choir. Some singers find it really difficult to even hear their own voice, and some singers are never satisfied with their singing. The main goal is to have a pretty flawless performance.

I noticed that perfectionism in singing techniques is much more important in Finland than in Canada, when I have recorded choirs. In Canada, the choirs concentrated on the feeling and passion in the performance, rather than on the technique. This may be because most of the recordings made with choirs there are recorded at live concerts.

2.5 The Listener's Demands

I listen to many choir recordings but I will not play the entire recording through if I do not hear interesting material being performed. Not even if it is a good choir. Also, I will not forgive bad acoustics. (Johanna Laukkanen, an Executive Director of Finland's Choir Director Society, Interviewed 1st of March 2008.)

I think that in Finland people always want to hear something new and exiting, and that is why there is so much of new choir music in Finland. What I noticed in Canada was that there are more choirs that are specialized on a certain repertoire, so that the listeners could find exactly what they want to listen. The choir music there was not margin music as here in Finland. You were also able to find more choir concerts in different venues there.

What the listener can not understand is if he/she can hear something weird or something that "does not belong there" on the recording. Especially in Finland, the recordings are made very flawlessly, so the listener expects a perfect performance without any mistakes. I think that in America, they are not that much of perfectionists in this way, and release more live recordings from concerts. I think that practice should land here in Finland too.

3 Recording a Choir

Recording a choir demands a lot from the engineer. You have to do the planning, the preparation, to think of the gear that you are going to use, and carry out the recording process as planned. In the following chapters, I will go through the different phases of this process, and what the engineer is supposed to do, and maybe what not to do.

Also, the functions and characters of the choir director and the producer will become clearer before, during, and after the recording process. I will go through their opinions on how they feel the recording process should go forward.

I will also go through the different recording techniques and the requirements of the acoustics, but only in the way that concerns choir recording.

3.1 Planning

Planning is the most important thing to do when starting your recording. Firstly, you need to discuss with everyone involved in the project, and come to an agreement on what and how everything should be done. Planning needs to be done with everyone involved in the project.

I find it useful to ask the 'client' to provide some examples of the kind of sound they are looking for, too, as this avoids any misinterpretation over the style of the recording. Any confusion at this early stage will result in complete chaos later on, so it is essential to make certain everyone knows what is going on. (Robjohns, H. 1999)

I think it is very important to find out what the wanted sound is and what it resembles. All misunderstandings need to be cleared out before carrying the project forward. Everything should be scheduled now, so that everyone knows what he or she needs to do in order to make the recording successful. Also, if you can not do something that is asked, it is better to say it now, than try to do something you simply can not do. Do not promise too much, and do not go beyond your skills.

Planning is very important because there are so many people involved and many different phases. It requires a lot in the recording process, when the timetables of the choir, the audio

engineer, the producer, the musicians and the recording place should match together. (Koivusalo, M. SULASOL 4/99 I.)

For some reason, I have gotten an image, where experienced engineers tend to lack on planning. They are outputting an image that they are so good that they do not need to do any planning. Some engineers say that they already know what they will do without planning, and will not even discuss with the client, because the client trusts their professionalism and fame. Some engineers say that they will not know what they will do, until they get to the recording venue, when the recording should already start. I think this is either laziness or not having enough time for it. Also, I think there is no time for planning at the point, when you are at the recording place on the recording day. To me it sounds unprofessional. Chapter 3.1.4 discusses the timetables further.

The main group had one specialist to be responsible of their own field of area: a producer, artistic producer, choir director, technical producer. In making records, this is a functional way to work and has been working globally for a long time. That is why we felt not to change that when we were starting the recording process. (Murtoniemi, M. 2005, 57.)

I would like to cast doubt on Mikko Murtoniemi and his comment about the working group. I personally think that there can not be too many people involved in the recording process, because the more people there are the more difficult the decisions become. I have noticed that the common practice would be only one producer, mainly an artistic producer, that takes care of the artistic side and notation, and one engineer with maybe an assistant to take care of the technology completely, and the choir director. There can be assistants of course, but I have noticed in all the projects where I have been involved that there are mainly these three people making the decisions when it comes to the recording. If there is a record company, it will take care of the tasks of a producer, which means taking care of the financial part, but it is not involved in the actual recording process otherwise.

3.1.1 Duties of the Choir Director

The choir director is known to be the person who is leading in front of the choir. He/she is considered to be in charge of the choir and honoured and obeyed by the choir itself. But the choir director has also other responsibilities that not everyone knows.

1. Preliminary work in practice, including organising and public relations work. This is before the actual working with the choir, and is presumed in order to be successful in working with the choir.
2. Preliminary work with music, including the choices when it comes to the repertory, and preparations for the choir practices and choir performances, also maintaining the musician talents of the choir director himself.
3. The actual choir rehearsals and performances.
4. The subjective consideration of the choir director, including self-criticism and consideration of making the interpretation and the music of the choir better, and also the dreams and ambitions of the choir director himself.

(Lehtonen, M-L. 1996, 26.)

When the repertory and material is practised well, or the concert tour is coming to an end, the choirs normally are ready to make a recording. After the decision of making a recording is done, and deciding where the recording takes place, the choir director has a lot to take care of. He is the main person in organising the recording and rehearsing the choir for it.

All the songs have to be sung in a concert at least once, or the material needs to have a "trial run", meaning a dress rehearsal before recording. I have to estimate if the songs are mature enough for being recorded. Normally we make a Christmas record during the spring and other recordings after the concert tour. But we do not make recordings that often, maybe every third year. It totally depends how fast the repertory recurrences. (Pekka Nikula, a Choir Director, Interviewed 15th of April 2008.)

It is my decision when the choir is ready to be recorded. Normally they are ready when the different voices are in balance, and the singers are able to understand and express the music well. A recording is only a document of that exact moment. The choir is always ready to be recorded, and then again it is never ready. All the time, the choir could be better, and there should be more and more talent on the recording. (Kari Turunen, a Choir Director, Interviewed 9th of April 2008.)

During the actual recording situation, most choir directors have a lot to do. Especially if there is no producer involved. Nevertheless, the choir director has to mainly focus on to the music and the actual performance. He/she is considered to be responsible of not only the material to be chosen on the recording, but the interpretation.

When there is an open, positive and encouraging atmosphere between the choir and the choir director, making of the recording is easy. It is important that the choir director is in charge of the relaxed atmosphere throughout the recording process. The better the choir singers trust to the fact that they sign well, the better the outcome will be on the tape. (Titta Lampela, a Producer, Interviewed 13th of April 2008.)

My role in the recording process is to drive forward the actual recording process and still stay calm. It is an exiting moment to start the recordings, and it normally takes about an hour before everything starts to go smoothly. (Kari Turunen, a Choir Director, Interviewed 9th of April 2008.)

Not everyone is able to conduct a choir. These people have to have a good musical education and background; also most of them are practising singing as well, or sing in choirs. The choir director has to have experience not only musically, but in managing people, and have the skills of a teacher. As an engineer you have to be able to create a contact with the director, so that you are able to understand each other. This can be hard but when you understand where he/she comes from, and who the director really is, then you are able to evaluate what he/she knows and does not know about recording procedures.

Nowadays there are much more talented singers than before, the level has risen up. In a way that is the role of the choir director in his work, when it comes to being a pedagogue and training the music. Of course, the level of the music being performed becomes higher as well, and this is why the choir director needs to keep up, and be able to work with more difficult music. You have to be versatile and comprehensive when it comes to music. That is something that the audience demands. (Kari Turunen, a Choir Director, Interviewed 9th of April 2008.)

3.1.2 Tasks of the Artistic Producer

The producer of the recording is either a person, a company or an association that finances the making of the recording. This term means a financial producer and not the artistic producer. Often the producer is a record company. The artistic producer is not entitled to copyright compensation according to the copyright law. (Gramex 2008.)

Every recording situation that is aiming for high quality needs an artistic producer (the score producer). The main tasks of the artistic producer are to get the best quality out of the orchestra, and take care of the fact that there is enough material, meaning that everything has been recorded according to the demands that are disposed. He will compile a plan for compiling the master tape. The artistic producer is in charge of the quality, and the approval of the masterized outcome. He is also in charge of the positive atmosphere in the recording situation, and the elimination of problematic situations. (Siniketo, J. 2007.)

The producer is the one behind the notes (Koivusalo, M. SULASOL 49/99).

The artistic producer (later the producer) observes and controls all the artistic work done during the recording. In order to get the best out of the choir, and to decide what the best takes are, the producer needs to be prepared to the recording situation, as well as the recording engineer. The producer has to be ready to work with the choir immediately in the recording process and know the songs beforehand.

I would like the producer to come to the choir's practice maybe once or twice before the recording. The producer needs to know the choir and be able to direct the image of the sound. (Kari Turunen, a Choir Director, Interviewed 9th of April 2008.)

Sometimes I have been in the practice of the choir or in their concert, but sometimes they send me a practice tape/cd. Often if I know the director, and the choir is familiar to me, I imagine the timbre of the choir while reading the notes of the songs. Very rarely the choir director has wanted to meet and go through the scores before the actual recording day. (Titta Lampela, a Producer, Interviewed 13th of April 2008.)

Normally, during the actual recording process, the producer sits beside the engineer and writes on the notes or to a notebook what are the best takes, and what happens in each take, if there are problems, and what kind. I always provide the producer headphones for the listening, and I have not met anyone wanting to have speakers for this purpose.

If there are problems with staying in tune, we are forced to record in smaller parts, and sometimes start to record from very peculiar places in the middle of the song. When this happens, most of my focus goes to "guarding" the pitch. Luckily this happens rarely and only when the singers are tired. (Titta Lampela, a Producer, Interviewed 13th of April 2008.)

The main things that the producer needs to observe during the actual recording are the timbre, the lyrics, the nuances, the rhythm, and the changes in the tempo. Also, the interpretation is on the responsibility of the producer. They are always looking for the soul of the recording.

Sometimes, but very rarely, I check from the tuning fork if the choir is maintaining the pitch of the song. I also write down the tempo and check it when the new take starts, or if I suspect that the tempo has changed too much. (Titta Lampela, Producer, Interviewed 13th of April 2008.)

There are also opinions about the tuning fork. I would also prefer a piano or some instrument to take the tuning from, but sometimes there are no instruments, and the tuning fork has to be used.

You should not use the tuning fork, because there might be small differences with the pitch between the takes, this makes it difficult to edit afterwards. Voices from the piano, and tempo from a metronome. (Koivusalo, M. SULASOL 1/00 III.)

The producer is not necessary. The recording can also be done with just the choir director and the engineer. You just need to have pauses between takes and listen to what you have recorded. After this, you check that everything sounds like it should. This way is much slower than with the producer, but it can be done. This will just make pauses to the recording process, and breaks up the concentration of the choir. (Koivusalo, M. SULASOL 49/99.)

I think this is true only when the engineer can not read notes. I know that engineers tend to just listen to the sound quality, but if you are able to listen to the sound quality while reading notes, it makes you an even better engineer. I think musical notes are also good to have beforehand, even when the producers are the ones in charge, when it comes to notation. I like to read the notes beforehand, and see how the structures of the songs go. Some engineers do not really like to, or do not have time to do this, but I find it very useful to know the songs, especially if there is no producer. Sometimes when I am efficient and happy with the sound, I read the notes while recording. Some engineers simply, depending their musical background, can not read notes. It is a good thing to know how to read them, especially when recording classical music, where editing according notation is one of the most crucial things.

I think, that any recording choir that is ready to invest in quality, should have a producer. Also, it is a big relief on the choir director to be able to concentrate on his artistic work and the interaction with the choir only, if there is a producer involved. I strongly think that the choir director has a hard time listening to the actual outcome at

the same time when conducting the choir. Although I do admit that it is a financial question for the choir to have a producer involved. (Titta Lampela, Producer, Interviewed 13th of April 2008.)

There are a lot of choirs in Finland that can not get a producer because of financial problems. The funds are limited, and many choirs run with the help of associations, or by grants. Instead of a professional producer, some choirs tend to use a person who is somehow involved with the choir, or a singer of the choir, who just is not able to sing at the moment, to observe the quality of the performance. In Canada, I noticed, that many of the choirs collected their funds with the entrance fees of their concerts, even if it was a concert in a church.

We have a vocal coach with us in the recording process, who will concentrate on the quality of the singing. She is kind of like a producer. (Pekka Nikula, a Choir Director, Interviewed 15th of April 2008.)

3.1.3 Assembly and Assistants

I know that as in most jobs, you not only have to be good at your discipline you also have to be good at managing people. This is really true of handling a recording session with a choir of 30 or 40 people! (Rowley, J. 2006.)

I agree with this, but I also think that the recording engineer has to be able to assign different people to do different things. You do not have to do everything. As an engineer, I think it is important to have dealt with the issues of the recording beforehand, and everyone's assignments to be given beforehand as well.

No matter what size the choir is, or what the assembly is, it is important that everything has been planned and scheduled, so that people do not have to be confused about what happens next, or what they should do. With children, I would imagine that the schedules need to be even more carefully done.

We cannot plan any long term projects with child choirs, because the members in the choirs change too rapidly. When we want to make a recording, we will record songs that have been rehearsed through out the year, basically no matter what songs there are. The recording session can not be too hard on the children, because they get tired

very easily and become very restless, if there are too many breaks. (Pekka Nikula, a Choir Director, Interviewed 15th of April 2008.)

An assistant is very useful to have, but in most cases the choir does not have enough money to pay for an assistant. If you need help with something, you should negotiate with the choir. If there are people who could help you on whatever you need, for example, helping you to carry your gear, or to keep track with notes during the recording, do not hesitate to ask.

I will work with another person, if possible a sound-engineer. I will explain to him what kind of sound I am looking for. Also I could be the sound-engineer and only work with an assistant. (Amandine Pras, a Producer and an Audio Engineer, Interviewed 16th of April 2008.)

3.1.4 Spent Time and Timetable Evaluation

I have been told many times that a project is half done, if you have organized it well. I tend to plan a lot in advance, and do the preparations before the actual recording, so that when the recording situation comes, I am able to do the setup and everything needed fast, but accurately. This is why a good timetable will save you time, and if you are able to stick with it, everything will go as planned. Also, if you are prepared according to plans, there will be no pressure or stress for the choir, the director or the producer. You are able to get the best out of them, and the best performance.

During the preparations, I have been mainly in contact with the choir director, or the spokesman of the choir. With them, I agree about the times and dates of the recording, the payments, schedules of the editing, etc. The negotiations are mainly done by phone or by email. (Titta Lampela, a Producer, Interviewed 13th of April 2008.)

I have done recordings during weekends, and normally it is the best to do it so, because it is the easiest time to have everyone there who is needed. It might even take couple of weekends for the actual recording time, to get an album recording done. During the week people have other works and duties, which will make them too tired for evening recordings. Also, you need to take care of the fact that the recording situation does not take too long. Even though it is good to have long sessions, and to have material recorded fast, there has to be pauses, and

lunch breaks, etc. It is good to have breaks when the song changes. Breaks within a song can create problems with pitch and tempo.

It is hard to say how much time you need to make a good recording. Some choirs can do it during a weekend, but often it might take even more time. The recording might take several days, and it demands intensive concentration from the choir, and that all singers are present all times. (Koivusalo M. 4-5/99 I-II.)

You have to make a schedule of reasonable times that you need for planning, gathering your gear, setting up, for sound check, for the actual recording, maybe for exporting the material, making the listening cds for the producer, editing, mixing, mastering and getting the final version on a cd. These estimated times should be given to the choir director and the producer, also probably to the spokesman of the choir, and to someone who takes care of the payments. Even though you are only estimating how much time you need for everything, it is important that the “client” knows approximately how much time it will take you to do all this. It will also determine how much you are able to ask for your services. There is a limited amount of time for preparations and for the actual recording (Rantanen, E. 2001, 37).

3.1.5 Payments and Costs

You should always remember that when recording acoustic music, it is always price vs. quality. The better gear you have and the more experience, the better quality you are able to get to the client. If you are a beginner in recording acoustic music, then you can not expect to get paid as well as engineers that have been doing it for years, but do not underestimate your talents or price yourself too low. This will lead into even bigger problems like getting bad reputation, or people are not convinced that you can do it. They might think you are “too cheap”.

Because of the low expenses, we have had a different recording engineer every time we have done a recording. Unfortunately it is like this, and sometimes I need to do more than be a choir director. (Pekka Nikula, a Choir Director, Interviewed 15th of April 2008.)

I personally always attach my pricing to the times that I spend on the project. Some engineers want to price themselves by the hour. But some engineers will give out a certain sum, for

example for the actual recording time, and a certain sum for the mixing time and so on. This makes it easier for the choirs to evaluate their budget and be prepared, when they know approximately how much the cost is.

Most of the choirs in Finland pay for the recordings themselves, and do not belong to a record company. I like to price myself differently between clients, and I know many engineers that do this as well. There are no certain prices for an audio engineer in this field, and you can pretty much price yourself freely. I only think that you should be aware of how other engineers price themselves, so that you are not overpricing or underpricing yourself.

Also, bargaining with the client is sometimes a part of the process. You have to agree with the client about prices beforehand, so that there are no surprises. Normally, you will make a suggestion of the costs to the client, also including a gear rent if you are renting gear for it. The client of course accepts, bargains, or refuses to work with you with your demands of the price.

Remember to make a contract in writing. This will make your life so much easier, and I know it because of experience. After you have everything on paper, you will not have sleepless nights. People tend to be reluctant, when it comes to agreeing the price before hearing the outcome, or want to test your talents first without paying. Do not go along with this, and show your talent to them somehow, for example with reference cds.

In Finland, you can find more information about payments and the methods of getting paid correctly from Verohallitus 2005, Salary or compensation for work, (<http://www.vero.fi/default.asp?article=4050&language=FIN>). Also the AES (Audio engineers society) at (<http://www.aes.org>) will help you with these issues in Finland and globally.

3.2 Preparations

The importance of practice cannot be praised enough. Even though it is not the engineer's fault, if the choir has not practised enough, you still need to be aware of what is going on. You need to be aware of the choirs activity, so that you know how much they are practising before the recording and where.

For the choir to work in a recording situation, it is important that the material is very well rehearsed, and that they have put the final touches to the performance. If the rehearsing is still incomplete, the recording of the choir might be very shaggy. The atmosphere will suffer because of it, and the final outcome will not be the same than with a well rehearsed repertory. (Titta Lampela, a Producer, Interviewed 13th of April 2008.)

After agreeing precisely what is required, the next stage is to reconnoitre the proposed recording venues (Robjohns, H. 1999). I think the engineer needs to visit the location where the recording will take place once on his/her own in silence, and later on with the choir to practice there, especially, if you are not familiar with the place. There might be surprises with the lights, buzzes, rattling roof, big highway nearby or something else, if you are not prepared and familiarized with the recording venue. Also, depending on the space and acoustics, you should take notice of the reverb time. It will help you to choose the gear and the recording techniques before the recording.

It is necessary to have good notepapers and sheets with you, without them you will be pretty much confused, and afterwards you can not find the takes and the parts that are needed. I like to write down my markings to the notation, or I will just write down the takes of each song, and a comment about the take, like what is happening in it, and if I think it is a take that would be used. Naming should be the same on your sheets as in the recording files.

3.2.1 Material to Be Recorded

Carefully choose the material you want to record, because it will define you as an audio engineer. If you always choose a choir that tries to sing harder material than what they are able to perform, it will affect on your engineering career. In a choir recording, the mistakes cannot be taken out easily, and it is pretty much impossible to even do so. It is better to start with material that can be performed well, even though the level of the music would not be high. Do not promise that you can correct their mistakes!

It is important to take care of the length of the music as well. A cd is able to take 75-80 minutes, but do not be accurate with that. There should always be a little time left for pauses between tracks, and for good overall functioning. A good thing is to decide between 10 and 15 songs beforehand for the cd, by calculating the estimated times of the songs. Some

engineers will not even accept more than an hour of material on to the record. These times can be taken at the practice of the choir. It is also good, if the material has variety in them, unless the cd is a complete composition of something, or from a certain composer.

The normal length for a choir record is around 50 to 60 minutes. The listener simply is not able to listen much more than that. (Kari Turunen, a Choir Director, Interviewed 9th of April 2008.)

There are really no rules for the length of the record, but you should avoid recording a record that has less than 40 minutes of singing. The buyers look at the length in the stores, and they will look down on records that do not have enough length, even if the price is lower. (Koivusalo, M. SULASOL 4/99.)

It is important to take notice that the choir should basically know the recorded material by heart, but normally they cannot do it. In my own recordings, I always ask the choir to put the notes in plastic pocket folders, and ask them to change the pages very carefully, so it would not make too much noise. You should also ask them to share the folders somehow, the fewer folders the better. Also, stands for the notes is a good thing, because there is less noise if the notes stay put, and it will save the energy of the singers when they are not holding them in their hands. Most of the professional choirs sing the songs from memory anyway, especially in Canada and USA.

3.2.2 Dress Code and Behaviour

Dress code is actually really important. Depending on, of course, if it is a live concert recording situation or a record recording situation. On a concert recording situation, I was advised, while recording in Canada, to always wear black, no matter what. *“You should wear black and something nicer at the concert recording.” (Mark Corwin, an Audio Engineer and a Professor, Interviewed 19th of March 2007)*

The clothes needed to be of a higher standard than normally. So, no jeans or t-shirts. Clothes need to be tidy and neat. A nice sweater for girls and a shirt, or collar shirt, for guys. Always long straight trousers. Shoes had to be festive. Sneakers were not allowed. (The Banff Centre dress-code rules for stage people) This was very strict. You could not go on stage to change

the positions of the microphones otherwise. It was a general behavior that engineers were dressed as festive as the audience.

You should know that as an engineer, you are responsible for all the recorded material and technology. Pretty much everything comes down to the engineer with the technology. He/she is the first person to be asked, when it comes down to the recording and the takes.

In time, when the engineer gets more reputation, the artists trust him more and do exactly like told. An engineer can even be feared in some situations. I tend not to go into that situation. I do not want the artist to be afraid of the recording situation, because you can hear it in the sound, and I bet it also makes the atmosphere weird.

In my own projects, I am always careful about what I promise to the artist. Also, technical details do not interest the artist or the client at all. Some engineers will not tell the artists anything about the microphones or the gear, because they do not want them to be afraid of the microphones, or because they do not want them to even notice the microphones. One engineer from Germany was ready to place the microphones in very funny places, so that they would not ever be in front of the artists. He was not concerned about the sound quality at all, because it did not matter to him. The main point for him was to capture and document the playing. He recorded mainly live recordings. I tend to tell the artists about the positioning of the microphone just enough, so that I could get a good sound also in live recording situations.

Some engineers even lie when it comes to technology, so that the client would not be worried. For example, I heard that one very famous engineer had the client for a listening session in his studio, and they could not agree about the amount of reverb. The engineer pointed a fader from the mixer where the client could adjust the level of the reverb. The client adjusted the level he felt was perfect. But the fact behind this was the client did not know that the fader was empty, and not assigned to anywhere. I do not approve of lying, but in some cases I am careful about what to tell the client. Even so, most of the engineers tend to be graceful with things. The recording situation should be easy for the artists, so that they can concentrate only on to their performance and nothing else.

3.3 Space and Acoustics

The recording place of the choir depends most on the size and the assembly of the choir. It is important for the engineer to know that no matter what size the choir is the recording can not take place in the studio situations. There are some studio spaces for these purposes, but there are not many of them and getting into them is more than difficult. The recording places for choirs are churches, concert halls and other big venues. (Rowley, J. 2006.)

I have noticed that the acoustic venue should be chosen carefully. It is not easy to change the acoustics on the recording afterwards. If the reverb time is way too long, and makes the sound smudgy, it is very difficult to take it of. There are some plug-ins for that, but they always affect the sound quality, and what we do not want is a space that sounds unnatural. It is very important that the space and acoustics do not irritate the ear during playback. Some engineers seem to think that you have found the acoustics perfectly, when the listener does not notice the acoustics, or does not have anything to say about it.

When you are looking over a potential recording venue, the kinds of things to look out for are the locations of power sockets and what kinds of plugs they need -- some churches and old buildings do not use modern 13A plugs! You also need to find out if there are likely to be any noise problems from equipment (heaters, chillers, lifts and so on), or from other people, traffic or planes. (Robjohns, H. 1999.)

Make sure that you can get facilities for a drink in rest periods and that there is adequate power (Rowley, J. 2006). I always check these things in advance. It is terrible to work, if you do not know where to handle the lights, or if the air conditioning is still on. You should find the people who are in charge of these things in advance, and agree with them on the things that concern the recording. In a couple of occasions, I have been really pulling my hair off, when the janitor has left the air conditioning on, even though we had agreed about a time when it was meant to be shut down. Luckily I had his telephone number.

3.3.1 Churches and Chapels

Some churches really are too big and can have a massive reverb that washes over everything, though of course some religious music is written specifically for this type of location (Rowley, J. 2006). I think this is true, and I avoid recording in churches that have a too long

reverb. This is a really important thing, because afterwards it is hard to shape the acoustics successfully. The decisions that you make, when it comes to the recording venue, are what matter, and what has the largest effect to the timbre of the choir.

I favour churches as recording places, because it is easy for the choir to sing there. With the closeness of the microphones you can eliminate and shape the acoustics very well. The long reverb is not a problem to the choir that much, but the church can not be too big. When you sing loudly, the space needs to fill out with the timbre, and when you sing quietly the sound can not disappear. Acoustics always depend on the recordable material though. (Kari Turunen, a Choir Director, Interviewed 9th of April 2008.)

The recording venue is chosen together with the choir director, because it depends on the choir and how they sound like. Some people prefer churches, especially when it comes to classical music. Pop, Gospel and Jazz choirs want a dryer sound and prefer concert halls.

Whenever I walk into a venue for the first time I always check out the natural reverb by making a single loud clap and listening and counting for the reverb to die away (Rowley, J. 2006). I also tend to sing or speak in the church. Kevin Austin, my professor in Electroacoustic Studies at Concordia University, Montreal, advised me always to check out the new acoustics by putting a friend or an assistant to clap their hands where the artist(s) will be located, and that you would stand yourself where the microphones would possibly be. He also advised me to walk through the entire space, while the assistant is making noise. Austin said that it is a better way to hear the acoustics objectively, because when you clap your hands you will hear more of the instant clap sound of your own hands, than how the clap really sounds like in that space.

There are different kinds of reverbs, and the length of the reverb does not tell everything about the sound of the space. The acoustics is formed by many different factors; the shape and size of the place, the materials of the walls, floors, and other surfaces, also the decoration affects on the sound of the space. (Koivusalo, M. SULASOL 5/99 II.)

Determining what the reverb should be, I found some figures where the desired reverberation times are indicated. The optimum reverberation time is thus a compromise between clarity (requiring a short reverberation time), sound intensity (requiring a high reverberant level), and liveness (requiring a long reverberation time) (Rossing, T.D. 1990, 469).

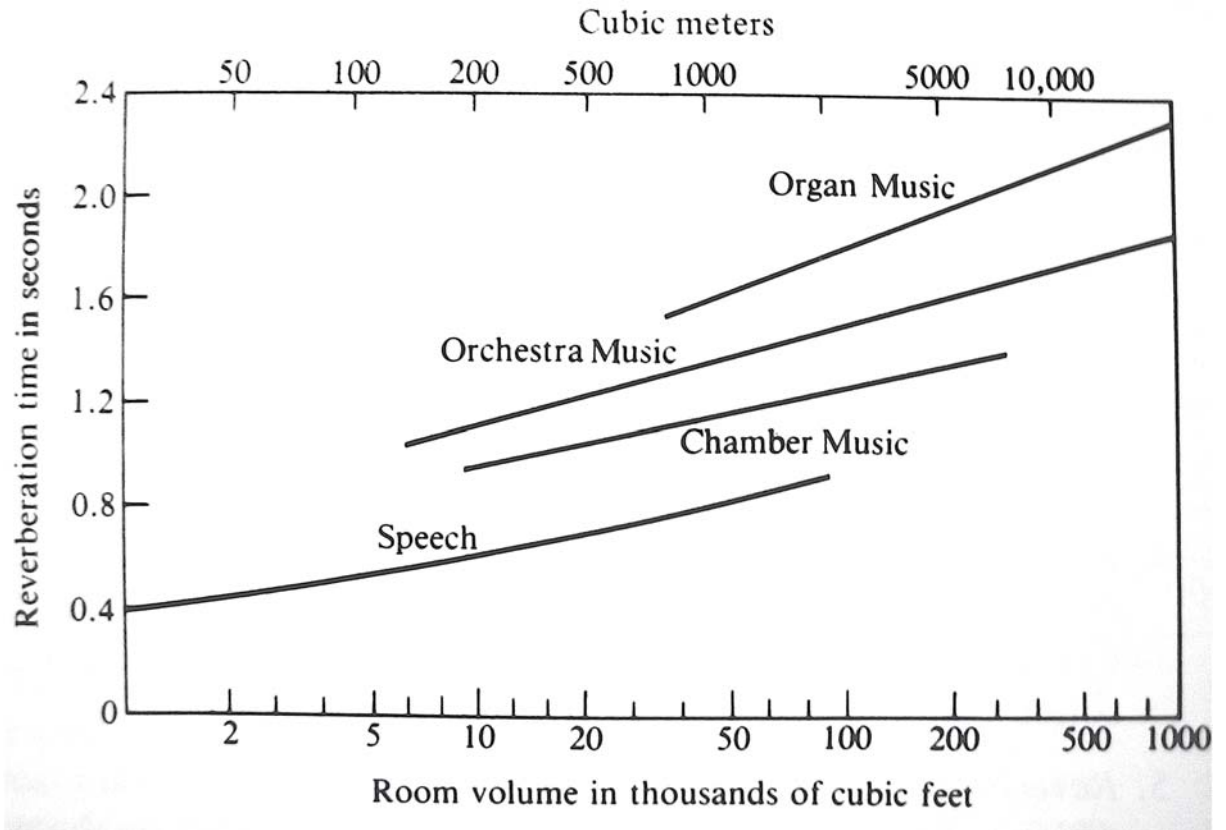


Figure 1. Desirable reverberation times for auditoriums of various sizes and for various functions (Rossing, T.D. 1990, 469).

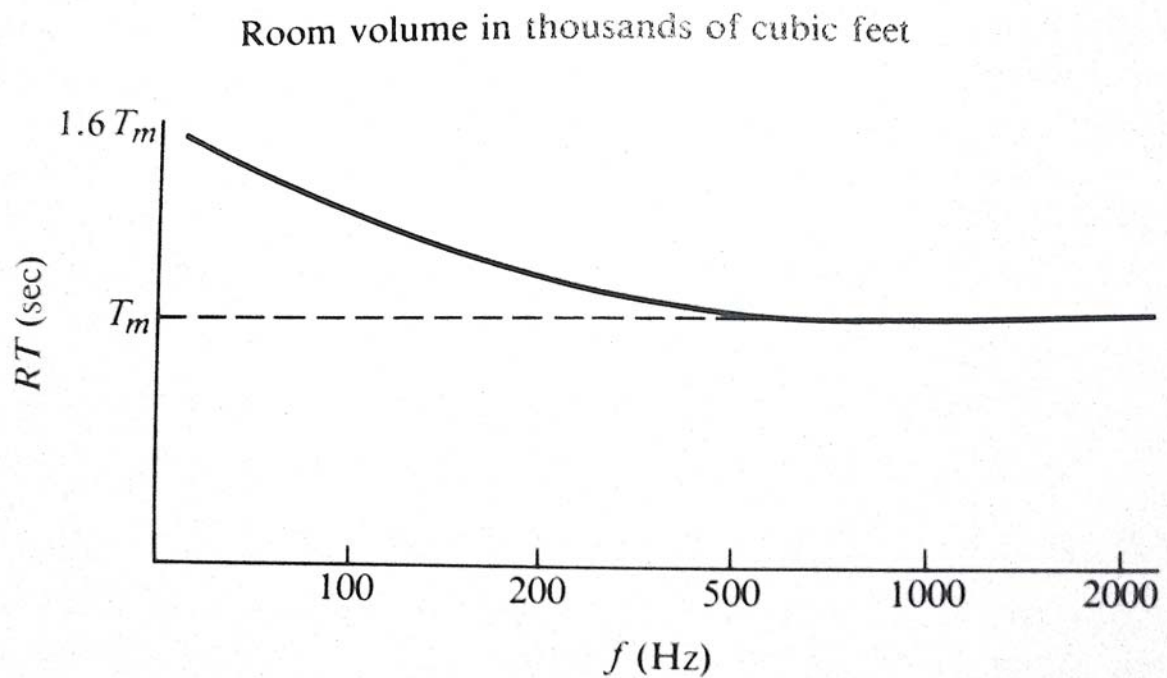


Figure 2. Variation of reverberation time with frequency in a good concert hall (Rossing, T.D. 1990, 469).

I really like it, if the reverb is somewhere between 2-3 seconds. In old chapels, it tends to be even more, but I really like these old chapels as well, because the sound in them is really warm and naturally smooth. The only thing is that there are not that many old chapels in Finland. Also, if the chapels are really old, they might not have decent power, in the same manner as some old churches. I have run into this problem a couple of times. Also, the traffic can be a big problem, especially in big cities.

Most old churches have a nice smooth reverb between 2 and 3 seconds but some large churches, Minsters and Cathedrals can have huge reverbs that can be a real problem. Some also have strange flutter echoes because of their layout where the sound bounces back directly off a wall making a repeat. Methodist chapels are often a pretty good size and can have really nice acoustics but really avoid chapels or any buildings with dome roofs as they can be a nightmare acoustically. (Rowley, J. 2006.)

This might be true with choirs, but with solo instruments I have liked the sound of a chapel. There are some engineers who prefer big spaces. I remember someone telling me that the bigger the place the better. I do not agree with that, and I do think there will be acoustical problems, if you are trying to handle a really long reverb, and handling a big space especially is a really hard work, when you are recording a choir or an orchestra. In choir music, the point is to get the singers sound good together, but the sound cannot get blurry and smudgy, and by that I mean too reverberant.

In wooden churches, the reverb naturally does not have enough low frequencies, and is dryer than a church made of stone. The stone church is more reverberant and has a fuller/richer sound. In some churches they have elaborated the acoustics with absorbing materials. It makes the speech clear, but the music that is performed there will suffer. You cannot do anything to “dead” acoustics. (Koivusalo, M. SULASOL 5/99 II.)

There are a lot of small churches around Finland, especially in the countryside, and most of the old ones are made of stone. They do sound good, and are out of reach of traffic and other noise. It is also easier to keep everyone involved there throughout the entire recording, than in a church located in the city central. But, I do think that a small church will not acoustically defeat a medium sized church. I would rather look for a good recording venue, than add loads of reverb afterwards.

Old churches can be very cold places in winter and remember it gets too dark to read music by 3 pm in winter, (I live in Yorkshire) (Rowley, J. 2006). I think that in Finland this is true in some cases, but nowadays there are a lot of lights that are pretty quiet, or do not make any noise. But I do not know choirs that would record during night-time like rock stars.

3.3.2 Concert Halls and Rooms

Concert halls for especially performing and listening music were built very late, when comparing to the history of music, at the end of 18th century during classicism. Until then the performances were held in churches and in courts. (Aro E. 2006, 45.)

The concert halls and other big rooms are mainly not good recording or performing venues for choir music (Koivusalo, M. SULASOL 5/99 II). Here you can definitely notice the difference between the Finnish way and the American way in recording venues. In Finland, only the churches are preferred as recording places. I like to record in both concert halls and churches. I think that more religious material can be better in a church, but I do not think that I would like to hear a folk music choir, a pop choir, a jazz choir or even a gospel choir in a reverberant church environment. Also children's' choirs do not sound good to me in a church, especially if they are singing something else than religious material.

We try to get the acoustics so that you do not have to change it afterwards. Normally we record religious and spiritual music in a church, and other songs in a concert hall. (Pekka Nikula, a Choir Director, Interviewed 15th of April 2008)

The three basic shapes for music halls are: oblong shaped shoebox, fan shaped hall that widens at the rear, and a horse shoe shaped hall (Aro E. 2006, 45).

A medium-sized room is better for control, and if you can get the mics enough far away from the choir, you can get the sense of space needed for classical recording. But be sure it's a room where the walls are not so close that you end up having trouble with reflections, and acoustic compression can also happen. If you have too large of a group in too small of a space, they can sing so loudly that the sound compresses itself; they overload the room, it gets loud and just caps. It is the weirdest effect you have ever heard. (Fuston L. according to Weiss D. 2006, 36.)

The most important quality of the concert hall is that you can hear the performance clearly enough. It is also important that the players can hear each other well. The bigger the hall they are trying to build, the harder the balancing between these issues is. (Aro E. 2006, 45.)

The halls where I have recorded have not been that big and also there have been issues with the reverb and bad reflections. Some halls have so called “dead spots”, meaning certain places on stage where the sound is being damped so well that you cannot hear the performer. Also, there might be problems with standing waves. A wavelike pattern that results from the interference of two or more waves; a standing wave has regions of minimum and maximum amplitude called nodes and antinodes (Rossing, T. D. 1990, 50).

You need to find these problems, and know where they are in the hall, before starting your recording. I always do some research about the recording venue from people who know the place, or if I can find someone who has recorded in that space before. This will make me acknowledge the possible problems and work around them. Recording any acoustic source in a nice-sounding space requires some careful listening and a lot of experimentation (Robjohns, H. 1999).

I found a list of qualities of what is considered as a “good” and “bad” acoustics in a concert hall. This might help you to find out what is required from a good recording venue, other than a church.

A number of studies have been made of various concert halls in order to determine criteria for “good” and “bad” acoustics. Beranek (1962) found 18 subjective attributes of musical-acoustic quality that can be related to concert hall acoustics. Among the more important are these:

1. *Intimacy*. A hall has acoustical intimacy when music sounds as if it were being played in a small hall. The time delay between the direct and first reflected sound should be less than 20 ms in order for a hall to be intimate.
2. *Liveness*. This is related primarily to the reverberation time for middle and high frequencies. The optimum reverberation time depends on size and function. A hall with insufficient reverberation is termed “dry”.
3. *Warmth*. This is related to liveness and fullness of a bass tone. Reverberation time at 250 Hz and below should be somewhat longer than at middle and higher frequencies.

4. *Loudness of direct sound.* The auditorium should be designed so that no listener is seated too far from the sound source (since direct sound decreases with distance). If the hall is too large, sound amplification may be necessary.
5. *Reverberant sound level.* The level of the reverberant sound, which will be the same throughout the hall, depends on the power of the source and the reverberation time.
6. *Definition or clarity.* The level of the early plus direct sound should be greater than the reverberant sound level at all locations.
7. *Diffusion or uniformity.* Good spatial distribution of the sound is achieved by diffuse or irregular reflecting surfaces, and by the avoidance of focused sound or sound shadows.
8. *Balance and blend.* This depends on the stage design. If the stage is wider than about 15 meters, the ceiling should be low (10 metres or less) and irregular in shape.
9. *Ensemble.* There should be ample reflecting surfaces to the sides and above the orchestra so that players can hear each other.
10. *Freedom from noise.* In order to allow sufficient dynamic range, the noise level should be less than NC-20, preferably less than the NC-15 curve shown in Figure 3 on page 27. (Rossing, T. D. 1990, 470-417.)

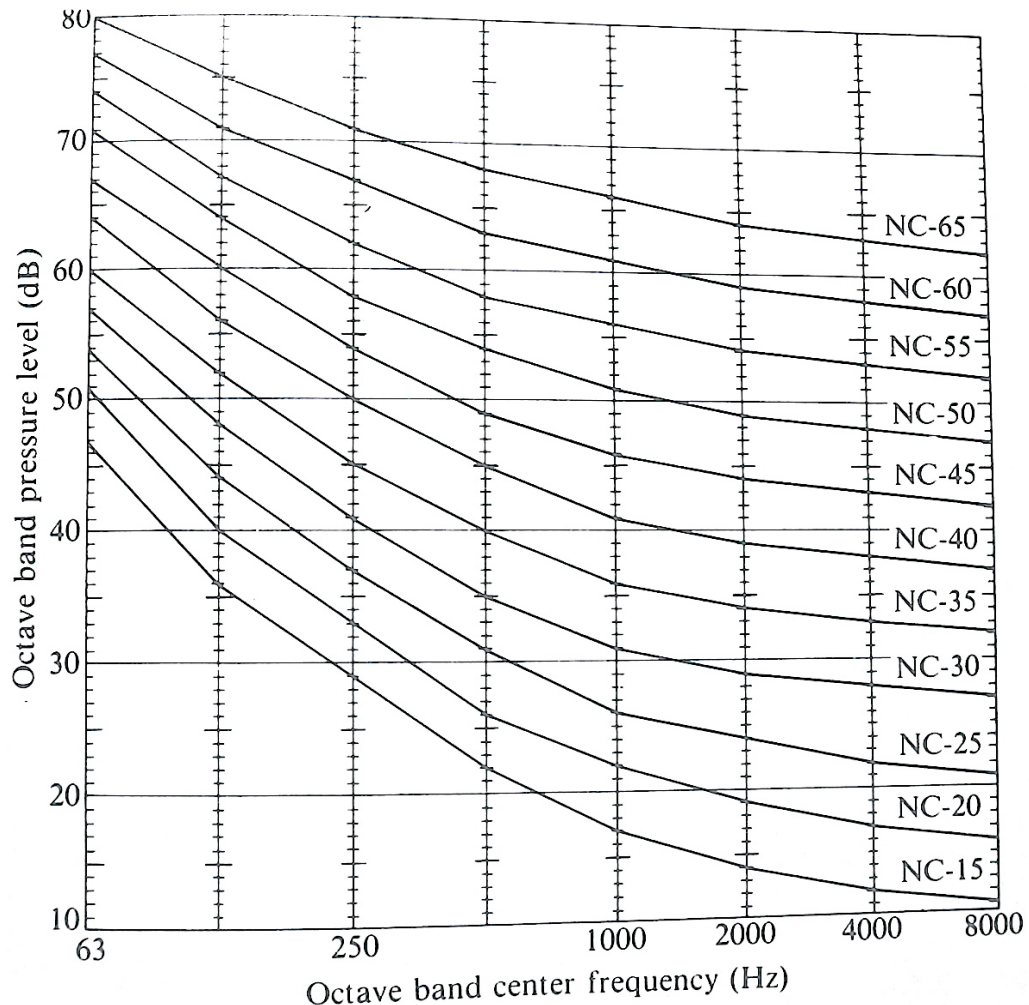


Figure 3: Noise criteria (NC) curves. (From *Noise and Vibration Control*, revised © 1988 Leo Beranek. (Rossing, T. D. 1990, 470-471.)

Along with these criteria, you should also take notice of the spatial impression, early decay time, echoes, flutter echoes, sound focusing, sound shadows and background noise. More precise information about them can be found from the book *The Science of Sound, Criteria for good acoustics* by Rossing T.D., on p. 472.

I would hope to have more good concert halls in Finland, but building them acoustically perfect is very difficult and expensive. In Canada, I noticed that there are plenty of concert halls, every university had their own, and not just one, but possibly even more than three. Concordia University, where I studied, had even their own chapel. Maybe in the future, we could get more concert halls build to the universities and schools. A gym hall or auditorium is not the same thing as a concert hall. *“Choirs are being recorded in churches, whether the repertory is religious or not. I think that there are not enough big halls or concert halls in Finland that have good enough acoustics. I hope there would come more concert halls.”* (Titta Lampela, a Producer, Interviewed 13th of April 2008.)

3.4 Placement of the Choir

Placement of the choir does not get enough attention, as I think it should. It is very important to take advantage of the acoustics and the space in the best possible way. It does not always sound perfect to the microphones, if the choir is placed as they are in practice sessions. It is good to change the place of an individual singer, if that singer is coming out too loudly to the microphones, or if the section is somehow not in balance.

If there are options in positioning the choir, I tend to do it so that everyone can hear each other as well as possible, and so that everyone are able to see the choir director. The main point is that the choir is in a position that they have discovered to be good earlier on. (Jouko Ahera, an Audio Engineer, Interviewed 12th of April 2008.)

There are options in shaping the choir in a half circle (an arc) or in lines. In surround, I had the choir shaped as an oval. Also, choirs with fewer members can be all separated from each other. I am interested in finding out with surround, if it sounds good when shattering the choir all around the space.

I might suggest something when it comes to the placement of the choir, for example if a stem will not stand out enough. When the positioning is done, I always ask the opinions and requests of the choir director. After we have recorded the first test takes, which are normally short takes of fast, slow, loud and quiet parts of the songs, I ask the choir director to listen the takes. Together with the engineer and the choir director, we discuss if something needs to be changed, whether it is the positions of the microphones or placement of the choir. (Titta Lampela, a Producer, Interviewed 13th of April 2008.)

It is important that the choir is able to sing well, even if the positioning has been changed. Sometimes the power of this simply is in the hands of the choir director and the producer. The engineer can make suggestions, but it might not always happen the way the engineer would want to. The singers need to feel good about their positions, and the choir needs to work as one when performing. This is one of the things that the engineer has to be flexible about, but I always suggest and talk to the choir director about these things, because they are trying to make a good recording too and might be flexible to my suggestions as well. You should always try, but not exaggerate.

Positioning of the children's' choir is the same as what we have in practice, and that is from left to right; soprano1-soprano2-alto1-alto2. If the concert hall is the shape of a

rectangular then the choir will be situated to the one of the gables at the shorter wall. Of course, in a recording situation you will try to find the exact position and define how much off the wall the choir will be. Sometimes we have been trying to put the choir standing on risers as well. (Pekka Nikula, a Choir Director, Interviewed 15th of April 2008.)

In concert halls, you are able to move the choir around more than in churches, where there is always a small stage, where to place the choir and solid bench rows throughout the space. In a recording situation, the choir is never on the balcony of the church. In a concert hall, I can decide if I want the choir more on the back of the stage, or in the front which will affect on how much I want to hear the sound of the space. Also, in surround there are possibilities of placing the choir around the microphones.

3.5 Gear

The gear needs to be high standard in order to make a good and natural sounding recording. Also, the gear needs to be familiar enough to the engineer, so that he/she is able to control the recording process, and so that it goes smoothly, when it comes to the technology. (Jouko Ahera, an Audio Engineer, Interviewed 12th of April 2008.)

I have noticed that some engineers prefer very high quality gear. Some engineers just think the simpler the better, and have only couple of microphones, and do it fast on to their laptop. I will basically use whatever gear I can get, but if I had my own gear I would rather have less and simple, and still, those little that I would have, would be high quality.

The engineer has to have experience in location recording but also he needs to have some pretty good equipment to make a good recording of a choir (Rowley, J. 2006).

I think that you can do good recordings with not so high quality. It all depends on what kind of choir music you are recording. Sometimes the quality and the price will meet on a lower level too. This is something that you would not hope for, but sometimes the engineer just does not have high quality gear, and sometimes the choirs are not able to pay that much for a recording either.

What you should think about before the actual recording takes place is what to take with you, and make a list of everything that you need with you. Here is an example of what gear to consider beforehand, take notice that it is from year 1999.

Before going on-location, you need to assemble a set of equipment such as this:

- microphones (low-noise condenser or ribbon type, omni or directional, free field or boundary, stereo or separate)
- MS matrix box (optional)
- recorder (open-reel, DAT, etc.)
- low-noise mic preamps (unless the mic preamp in your recorder is very good)
- phantom-power supply (unless your mic preamp or mixer has phantom built-in)
- mic stands and booms or fishing line
- stereo bar
- shock mount (optional)
- microphone extension cable
- Dolby noise reduction (optional)
- mixer (optional)
- headphones and/or speakers
- power amplifier for speakers (optional)
- blank tape
- stereo phase-monitor oscilloscope (optional)
- power strip, extension cords
- notebook and pen
- tool kit

(Bartlett, B. 1999.)

3.5.1 Microphones

When you are planning your gear for the recording, I think it is most important to start with the microphones. In acoustic recording, it is the most crucial thing with regards to technology, and it defines your sound for the entire recording. The sound that they define and the acoustics cannot be changed that much afterwards. If you have microphones that are not suitable for recording on location, and especially for acoustic music, then unfortunately you are not able to get the best of your recording, no matter how good the choir is.

Choirs inherently have a huge dynamic range and some quality microphones are an absolute first starting point when considering making a recording of a choir (Rowley, J. 2006).

I tend to use Schoeps (www.schoeps.com), Neumann (www.neumann.com), and AKG (www.akg.com) microphones myself. Also I really like the B&K DPA 4006 microphones (www.dpamicrophones.com) because of their accuracy and brightness, and because they are omni microphones, they pick up everything around them well, including lower frequencies. I have also found some Brauner microphones (www.brauner-microphones.com) interesting. Even the cardioid models are really accurate and bright with the stereo imaging.

I normally use microphones like Schoeps or Neumann for main stereo pair and AKG 414 for ambience microphones (Ari Koivumäki, an Audio Engineer, Interviewed 4th of March 2008).

Which microphones exactly I will use depends of the hall and what I can use. I will have a preference for Schoeps and Neumann, why not DPA. (Amandine Pras, a Producer and an Audio Engineer, Interviewed 16th of April 2008.)

Fuston used two mics per part for the 50-piece S.A.T (Soprano/alto/tenor) group for a total of six mics, using Neumann KM 84s on the men and Audio-Technica 4050s on the women, recording through a Millenia Media HV-3 preamp into a iZ Technology RADAR 24 hard disk recorder. (Weiss, D. 2006, 36.)

Some microphones have been qualified to be “cheaper” sounding microphones than others. Usually the price tells you something about the quality, but not always though. Audio Technica microphones have been qualified as “cheap” microphones among engineers, but depending how you use them, they can work well for your purpose. I would compare the microphone to a one that I know, if I do not have experience about the exact microphone, or

have not ever used it. It is also good to find out how other engineers have used the one you have not.

For sharp imaging, the microphone pair should be well matched in frequency response and polar pattern. Be sure both mics are the same model number, and match their levels when picking up a sound source in the center. Or use a stereo mic, which mounts two mic capsules in a single housing for convenience. (Bartlett, B. & Bartlett, J. 2007, 118.)

I would prefer all the microphones to be either the same model or a matched pair in the stereo pair, and also if doing surround you should have each pair at least to be a matched pair, the best would be to have same microphones especially in the surround microphone positioning bar. Otherwise your sound will not be coherent.

There are also stereo microphones that are trying to get their way to classical recording techniques. I have only met one engineer who uses it for recording classical music, so I can not say about the sound quality, but I do know engineers that do not like them because with a stereo microphone you can not get the tracks separated while recording. I have not seen these microphones in any of the schools I have studied for classical music recording purposes. So I would like to cast some doubt on the comment that I found about the sound quality and the appreciation of these microphones:

A stereo microphone combines two mic capsules in a single housing for convenient stereo recording. Simply place the microphone about 10-15 feet in front of a band, choir, or orchestra, and you'll get a stereo recording with little fuss. In general, a stereo microphone is easier to set up than two separate microphones, but it's more expensive. (Bartlett, B. & Bartlett, J. 2007, 104.)

3.5.2 Preamplifiers and Converters

It does not matter, if you record with your laptop or a hard drive recorder, if the quality is good and you are able to control the recording easily. *"The recorders should have the best possible resolution that you are able to get."* (Ari Koivumäki, an Audio Engineer, Interviewed 4th of March 2008) Today it is not enough to record the cd quality (44.1 kHz and 16 bit), because in recording acoustic music the resolution has a big difference in the outcome. By recording as high resolutions as possible, and to record at least 24 bit, you are able to get a lot

better sounding recording. For classical music the resolution to be more than 44.1 kHz or 48 kHz is very important. Engineer already record at least 96 kHz. I have been testing this, and you should test yourself too, so that you can hear the differences in higher resolutions especially after you have converted them on to a cd.

You need a power supply for condenser microphones: either an external phantom-power supply, a mixer or mic preamp with phantom power, or internal batteries. A low-noise stereo mic preamp (or low-noise portable mixer) lets you make recordings free of electronic hiss. (Bartlett, B. & Bartlett, J. 2007, 122.)

For preamps, converters, ect... I use what is available or what I could rent, I just try to avoid bad ones as Digidesign... (Amandine Pras, a Producer and an Audio Engineer, Interviewed 16th of April 2008.)

There are some good preamps that I have used, for example Avalon (www.avalondesign.com), and good converters, for example Apogee (www.apogeedigital.com). Also some others, like Lavry (www.lavryengineer.com) and Meitner designer (www.emmlabs.com) converters, and Millenia (www.mil-media.com) and Focusrite (www.focusrite.com) preamplifiers are of good quality.

The most used software for recording classical music is Pyramix (www.merging.com). Other most used software, for example, are of course Pro Tools (www.digidesign.com) and Sadie (www.sadie.com).

3.5.3 Stereo Bars and Stands

A stereo bar is an important tool when trying to get your stereo image perfect. It helps you to place your microphones on an accurate distance from each other and on certain angle. There are bars like these for surround purposes as well.

A useful accessory is a stereo bar (stereo microphone adapter, stereo mic mount). This device mounts two microphones on a single stand for coincident or near-coincident stereo recording. Along stereo bar can accommodate spaced-pair miking. (Bartlett, B. & Bartlett, J. 2007, 123.)

There are a lot of different models, but I have preferred, because of the accuracy, the Audio Engineering Associates (AEA) Stereo Microphone Positioner (SMP), (http://www.wesdooley.com/aea/Microphone_Array_Positioners.html).

When recording classical music and choirs, the microphone stands need to be higher than a normal microphone stands. There are bigger microphone stands manufactured for these purposes. Sometimes, when I have not been able to get my hands on a higher stand, I have used some stands that are made for lighting gear.

Stands are more suitable for recording rehearsals or sessions with no audience present. The mic stands should have a tripod-folding base and should extend at least 13 feet high. Some suitable products are telescoping photographic stands (available for camera stores such as www.prostudiousa.com). They are lightweight and compact. Other examples are Shure S15A (www.shure.com), Quik Lok A85 (www.quicklok.com), AEA-13MDV (www.wesdooley.com), K&M 21411B, and various models at www.micsupply.com. You can use baby booms or stand extenders to increase the height of regular mic stands. (Bartlett, B. & Bartlett, J. 2007, 122-123.)

The normal solutions are either to suspend the microphone from a catenary wire rigged across the hall from points high on the side walls, or to use a 'Cathedral stand'. The former idea, although popular in churches, was not possible or appropriate on this occasion because there were no suitable fixing points and it would have taken too long to rig and de-rig. Consequently, we elected to support the main microphone, in its shockmount cradle, at the end of an Ambient Jumbo Pole, which is the modern lightweight equivalent to the traditional Cathedral stand. This carbon-fibre pole can be extended to over nine metres in length, but is light to carry, easy to adjust, and very fast to rig, move or de-rig by just one person. A heavy-duty tripod with an adjustable clamp holds the pole at any desired angle with complete stability, and the microphone is counterbalanced by a sandbag attached to the opposite end of the pole. (Robjohns, H. 1999.)

In concert halls, I have hanged microphones above the choir many times. I have had three omni microphones as the left-centre-right line above the centre line of the choir. This makes a lot more to the sound than just the stereo pair, and is very ideal when recording live concerts. I have used this combination with the stereo pair and side microphones. Each microphone was hanged with a thick string that would hold the microphone's weight.

You can mount the microphones on stands or hang them from the ceiling with nylon fishing line. Make sure that the fishing line's tensile strength exceeds the weight of the mics. Check legal safety issues with hanging mics; different rules apply in different places. Stands are much easier to set up, but more visually distracting at live concerts. (Bartlett, B. & Bartlett, J. 2007, 122-123.)

It is good to remember that different choir directors have different opinions about microphone stands on stage in a live concert. Some directors do not approve of them at all on stage, so you are not able to put any spot microphones, and the main pair with a side pair also needs to be off the stage. You should always negotiate about this and the positions of the microphones with the choir director, and find out where the stands would not distract the artists. The choir directors are mostly willing to compromise.

3.5.4 Headphones, Playback and Monitoring

When I worked for YLE, I worked from a mobile unit car outside the church. It was really easy to work in it, because I was able to listen back easily between takes with speakers. Without the mobile unit, it is much more difficult to build a listening space to the church itself. Monitoring with headphones is always more problematical than with the speakers. (Ari Koivumäki, an Audio Engineer, Interviewed 4th of March 2008.)

The reality is that not everyone is able to have a mobile unit car for the recordings. I know also a lot of engineers, who always prefer headphones instead of speakers, when it comes to recording on a location. This is because they think when listening through speakers in a place that is not familiar to them, and not close to the acoustics of a studio space, the sound gets fabricated, and it is even harder to detect how the recording really sounds like. The wrong reflections will lude your ear too much. Speakers should also always be measured before listening to prevent the listening from crossing. This is problematic with both stereo and surround.

I always use my headphones, Beyer 770Pro, but if possible, I would prefer to monitor with loudspeakers and just check with the headphones as a reference (Amandine Pras, a Producer and an Audio Engineer, Interviewed 16th of April 2008).

I personally prefer headphones at the moment. I would like to use both the speakers and headphones, but I think it might mess my ears. Speakers in different spaces always sound different, and the listening place is always different, because the location is always different, but the headphones always sound the same to your ears. Especially, if you use the same pair of headphones every time, which I really recommend. I have a pair of Sennheiser HD650 and Sony MDR-7506, but it is more important that you are familiar of the sound of your headphones, and know what sounds good and what bad. I have been told that headphones, which are not boosted in any frequencies, and which are clear and somewhat bright, are good for recording classical music, because you are able to hear every single detail, when the headphones are accurate and separate every sound well. Also, I think that carrying good speakers to a location is a millstone, but remember to bring a small speaker for talkback at least. You got to have talkback because it will make your recording process much easier.

When you're recording a choir live, the foldback is always an issue. If you attempt to use speakers and get them loud enough so the choir can really get into it, you'll always end up with as much monitor bleed as you have choir in your mics. (Fuston L. according to Weiss, D. 2006, 36.)

There are a lot of problems when recording a choir in a live concert that needs a foldback. Pop and jazz choirs especially need foldback. When recording them, you need to take into consideration that you cannot use microphones that are too sensitive, so you need to forget the good recording microphones, otherwise you will get feedback into the monitors more easily, and make it a nightmare for the person doing the live mixing. Of course, the sound quality suffers at this point, and we all know what shure microphones sound like, when being recorded with vocals. There are also always problems with the pitch and their ability to hear themselves when using foldback. I have not found a solution to fix it, but I would figure that the tip of Lynn Fuston would be helpful.

If the volume isn't loud enough coming back, they'll proceed to pitch lower. It's a well-known phenomenon: If you put headphones on your head, you'll get a pitch center. Then when you lay them in your lap, you'll notice the pitch goes down drastically. What I've been known to do is pitch up in varying degrees so their singing is coming back in tune with the track. Don't tell the choir you're doing it, though! What they don't know won't hurt them, and don't take that step until you hear them. Frequently, that's what is needed live with a large group of non-studio singers. (Fuston L. according to Weiss, D. 2006, 36.)

3.6 Recording Techniques

Most of the development of stereo recording as we know it today happened in the very early '30s, almost simultaneously in America and the UK. In the USA, Bell Laboratories were working on systems using spaced microphones under the direction of Dr. Harvey Fletcher. Meanwhile, in the UK, a very clever man called Alan Blumlein, working for EMI, was developing an alternative system which relied on coincident microphones. (Shure, 2007.)

Different Schools in recording classical music have long roots in the history of recording. They define the different ways and techniques of making a recording. Today, the different Schools are divided in different ways, because the newer generations have been taking over the field in recording, and also the new ways of technology are providing new methods to the recording situations. The old Schools are still being taught, so that they would not be forgotten, and because it gives a good base to the recording engineer.

I measure the distance between the spot mikes and the main to put the time alignment, I will measure the all thing only if I have to do it again for the same record or in the same hall (Amandine Pras, a Producer and Audio Engineer, Interviewed 16th of April 2008).

Mainly, the Finnish ways and methods of recording classical and acoustic music come from the European “Tonmeister” technology also known as the German School.

3.6.1 The European “Tonmeister” Technology (German School)

Stereo recording became known for Alain Blumlein’s various stereo recording techniques. He presented 1931 a technique where two channel are engraved to the same soundrut on a disc in an angle of 45 degrees (Alaspää A. et al. 1977, 15). Along with AEG (Allgemeine Elektrizitäts-Gesellschaft) in Germany, musique concrète, electric studios between 1951 and 1953 and great names like Karlheinz Stockhausen (a German composer), every detail could be accurately calculated and recorded (Burkholder J.P. et al. 2006, 926-927).

Especially the Deutsche Grammophon record company developed the recording techniques of classical music since 1930, and they had engineers called the Tonmeisters in charge. The German School is all about the education, where they combine the

acknowledge of the conductor (bandmaster) and the audio engineer. (Ari Koivumäki, an Audio Engineer, Interviewed 4th of March 2008.)

The Tonmeister Technology started as a training manual for German recording engineers to learn the art of recording classical music for broadcast and commercial release.

The European "Tonmeister" model, which seeks to merge technology with musical artistry to create a higher-level expert in the presentation of music for mass consumption. In Tonmeister, the sound recordist assumes an integral part in the creative process. (Bokser, H. 1995.)

The recording methods in the European "Tonmeister" technology (German School) are based on mathematics and physics. The hearing was based on those calculations. In other words, the measurements and the placing of the microphones relied on mathematics and physics, so that it is already assumed to be known how it sounds like, just by knowing the numbers and calculations.

The Music and Sound Recording (Tonmeister) programme, established in 1970, is aimed at those who are primarily concerned with the theory and practice of sound recording, but who also wish to develop their musical knowledge. (University of Surrey. 2008a.)

This method is based on the way that when you have made calculations of a certain acoustical place, and the positions of microphones in that space, those are the best places to the microphones in that place, because it follows the exact ways and laws of the physics. In other words, everything else that differs or is placed differently is wrong.

Tonmeister is most often found as a job description in the music and recording industries. It describes a person who is a sound master (a literal translation of the German word, which applies to women equally as much as men): a person who creates recordings or broadcasts of music who is both deeply musically trained (in 'classical' and non-classical genres) and also who has a detailed theoretical and practical knowledge of virtually all aspects of sound recording. Both competencies have equal importance in a Tonmeister's work. (Wikipedia. 2008)

In time, and still today, these methods have raised a lot of criticism among the recording engineers and studios. They are questioning the fact that does it really sound good, and whether it is the one and only way to do a good recording. In time, the German School has adopted more features from other Schools, and methods on listening more, and not to be so strict, when it comes to placing microphones and other recording techniques. Also, the

different situations and different players, instruments, everything that is involved affects the sound. It is hard to determine, if it sounds good according to mathematic formulas because of these factors that change the sound, and this is what is revoking the German School's technical formulas.

Even today, there are requirements based on mathematics and physics, when applying to the Tonmeister schools. Tonmeister Institutes in Germany are Universität der Künste in Berlin, Erich-Thienhaus-Institut (ETI) der Hochschule für Musik in Detmond, Hochschule für Film und Fernsehen (HFF) in Potsdam.Babelsberg. Tonmeister Institutes can be found also from Austria (Universität für Musik und darstellende Kunst in Wien), Netherlands (Royal Conservatoire in Haag) and Canada (McGill University in Montréal). The most known Tonmeister School is the University of Surrey in Great Britain and here is an example from their requirements:

Mathematics, Music and Physics to A level or equivalent is required. This may be evidenced by gaining appropriate qualifications or by passing written tests at interview. Music Technology A level together with ABRSM Music Theory Grade 5 is acceptable in place of Music A level. Musical performance proficiency equivalent to ABRSM Grade 7 is desirable. (University of Surrey. 2008b.)

3.6.2 The American Way of Recording (Western School)

I believe that the Western way (meaning all the other School methods and ways of learning how to record sound) of recording classical music is more relaxed than the German School, even though it is pretty well linked with the German School. The Western way is trying out different recording methods, and discovering new ways of recording music, and sound is searched mainly by ear, rather than through mathematics. The methods are normally not as calculating as in the German School. It seems that it is forgiving, when it comes to techniques even if not recorded accurately. It is enough, if the recording sounds good. Basically, it does not matter how the recording has been recorded, if it sounds good for its purposes. Also, the methods are not as strict as in Europe, and I think this is so because of cultural and political differences.

In multitrack recording, techniques are continuing the same traditions that have been in Europe and in the USA for the entire recording history; the Americans have always favoured

using separated microphones, while in Europe, especially in Germany and Great Britain there has been a habit of using the main microphone with supporting microphones. These same traditions are continuing in the field of surround recording as well. (Aro E. 2006, 125)

3.7 Microphone Positioning

There are numerous different ways to place the microphones, when you are recording a choir. Every engineer has their own ideas and ways to do it of course, but it is good to know different ways in order to find the one you like the best, and because every recording situation is different, you can not always use the same technique.

Nothing has more effect on the production style of classical music recording than microphone placement. Miking distance, polar patterns, angling, spacing, and spot miking all influence the recorded sound's character. (Bartlett, B. & Bartlett, J. 2007, 128)

There seems to be two different ways to record the choir; basically two main Schools of thought on how a choir should be recorded. One way is to record every singer separately, and the other one is of course with stereo pair recording.

Another popular way of recording a choir is separating the parts (soprano, alto, tenor, bass, or SATB) and tracking each one separately. This gives more control in the mixing environment, like if the soprano overpowers everyone else on a line, you can pull them back. This method will give you 4 tracks (or however many you use) to play with, rather than the 2 or 3 with stereo. (Weaver, A. 2007)

When using a stereo recording technique, the sound is natural, like you are experiencing the music yourself in the audience. I personally prefer to record a little closer because of the clarity, and because I want the choir to be bigger and fill the entire stereo image. Of course, placing them too close will make the first row of singers way too loud, and at the listener's face basically, so you might want to avoid that.

I place the microphones where I think are the optimal places towards the choir. Pretty much always in a sound check, I need to change the positioning anyway, a little bit to the one way or another. It is important that the choir director listens back the first test take, and approves the acoustics that the engineer is capturing, and that will follow throughout the project. If there is too much or not enough acoustics, or the stems of the

choir are not in balance, it is pretty much impossible in most parts to change them after the recording is done. (Jouko Ahera, an Audio Engineer, Interviewed 12th of April 2008.)

The microphones must be placed closer to the musicians than a good live listening position. If you place the mics out in the audience where the live sound is good, the recording probably will sound muddy and distant when played over speakers. That is because all the recorded reverberation is reproduced up-front along a line between the monitor speakers, along with the direct sound of the orchestra. Close miking (5-20 feet from the front row) compensates for this effect by increasing the ratio of direct sound. (Bartlett, B. & Bartlett, J. 2007, 128.)

Finding the right places for the microphones come only through experimenting, such as by moving the microphones back and forth. From there on, listen to the sound with your ear. Go ahead and stick your head in there, listening at various spots to find the "sweet spot". Move the microphones in and out. You most likely want to keep them centred for your stereo sound. Try raising and lowering them too, because it really makes a lot differences in the sound. All I can say is – experiment. After you do a few choirs, you will know what a good choir recording will sound like. This will help you a lot in setting up the microphones, and in listening for a good sound.

Eventually, you'll find a sweet spot, where the direct sound of the orchestra is in a pleasing balance with the ambience of the concert hall. Then the reproduced orchestra will sound neither too close nor too far. (Bartlett, B. & Bartlett, J. 2007, 128.)

With the stereo pair, there is pretty much always another stereo pair further back of the space, as the ambience pair. These microphones are further apart from each other as well. With these microphones, there is a lot to adjust, and you simply need to just try what the perfect height is, and how far away you need to place them. The only thing to remember is that you need to be careful not to place them too far away because of the delay in the reverb and the direct sound. Some engineers place them towards the backwall to prevent the noises from the audience. Even though there are suggestions, and some techniques considered as the "right ways", there really is no right technique.

According to Delos recording director John Eargle, the distant pair should be no more than 30 feet from the main pair, otherwise the signal might simulate an echo. You record the two pairs to a multitrack recorder and mix them back in the studio. The advantages of this method are as follows:

- It avoids pickup of bad-sounding early reflections.
- Close miking reduces pickup of background noise
- After the recording is finished, you can adjust the direct/reverb ratio or the perceived distance to the ensemble.
- Comb filtering due to phase cancellations between the two pairs is not severe because the delay between them is great and their levels and spectra are different.

(Bartlett, B. & Bartlett, B. 2007, 129.)

Here are some examples of microphone placement in classical recording situations, just to give you an idea how the microphone positions might be:

If it's without orchestra, I will make a main system with a couple of 2 omnis (between 30-50cm, with or without angle) plus 2 hottriggers with 2 omnis as well to create the wide. If it's contemporary music, I may have some spot mikes (cardio) for each different kind of voice. It depends also if the hall acoustic is dry or not.

If it's with orchestra, I may only work with spot mikes, cardio (but not too close and quite high), for each different voice, and/or handle a main system (with cardioids as well) up to the choir. (Amandine Pras, a Producer and an Audio Engineer, Interviewed 16th of April 2008)

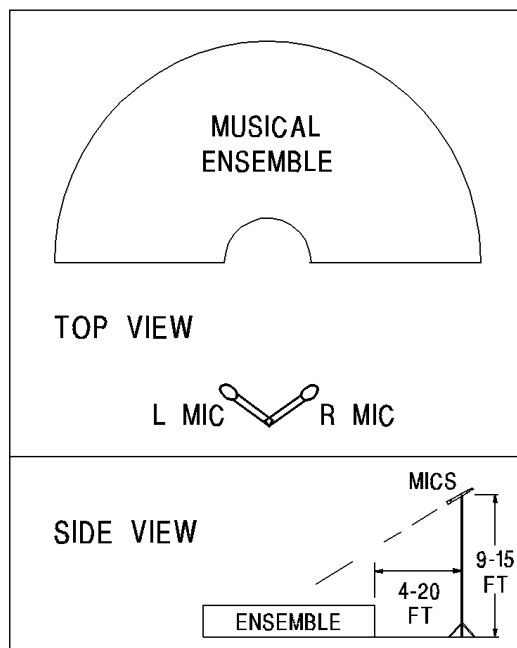


Figure 4. Typical microphone placement (Bartlett, B. & Bartlett, J. 2007, 126).

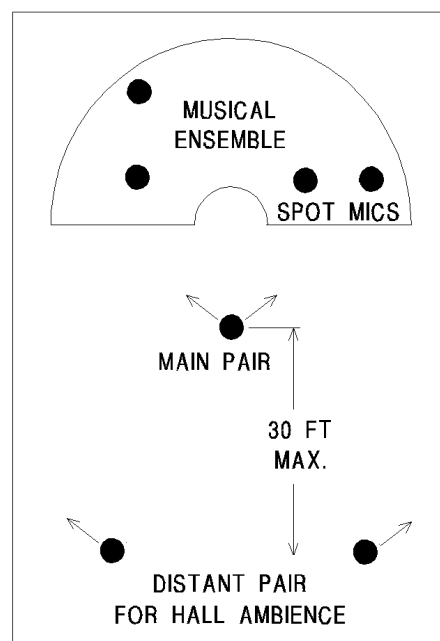


Figure 5. Typical microphone placement with main and distant pair, with spot mics (Modified picture of Bartlett, B. & Bartlett, J. 2007, 130).

3.7.1 Stereo Techniques

There are a number of different stereo recording conventions that different engineers favour but essentially you are looking to produce a stereo picture of the choir so that you can hear the different sections but not necessarily the individual singers. (Rowley, J. 2006).

With the stereo picture, you always need to think that you will capture the choir like it is, and the way it sounds like. Pretty much always, there is the main stereo pair, and the ambience pair somewhere at the back of the recording venue. There are of course different positionings for the main stereo pair, and I think these are only matters of opinions what stereo positioning the engineers like to use. Also, I think that it completely depends on the sound that is wanted.

There are different stereo positionings to get clarity and separation, and techniques to get more acoustically mixed sound with not that much clarity. I have noticed myself that in Canada, the engineers tend to record much closer to get more of the closeness effect than here in Finland, where we tend to place the microphones rather far away.

There are quite a lot of different ways how to place your stereo pair, and they are divided into certain techniques.

Comparing the Four techniques

1. Coincident pair

- Uses two directional mics angled apart with grilles touching.
- Level differences between channels produce the stereo effect.
- Images are sharp.
- Stereo spread ranges from narrow to accurate.
- Signals are mono compatible.

2. Spaced pair

- Uses two mics spaced a few feet apart, aiming straight ahead.
- Time differences between channels produce the stereo effect.
- Off-center images are diffuse.
- Stereo spread tends to be exaggerated unless a third center mic is used, or unless spacing is under 2-3 feet.

- Provides a warm sense of ambience.
- Provides excellent low-frequency response if you use omni condensers.
- Tends not to be mono-compatible, but this might not be audible.

3. Near-coincident pair

- Uses two directional mics angled apart and spaced a few inches apart horizontally.
- Level and time differences between channels produce the stereo effect.
- Images are sharp.
- Stereo spread tends to be accurate.
- The hall sounds more spacious than with coincident methods.
- Tends not to be mono-compatible.

4. Baffled-omni pair

- Uses two omni mics, usually ear-spaced, with a baffle between them
- Levels, time, and spectral differences produce the stereo effect.
- Images are sharp.
- Stereo spread tends to be accurate.
- Excellent low-frequency response.
- Good imaging with headphones.
- The hall sounds more spacious than with coincident methods.
- Stereo spread is not adjustable except by panning the two channels toward the center.
- More conspicuous than other methods.
- Tends not to be mono-compatible, but this might not be audible.

(Bartlett, B. & Bartlett, J. 2007, 117-118.)

Inside of these techniques, there are mainly these stereo mic techniques that I found from the books *Recording Music on Location* by Bartlett, B. & Bartlett, J. and *Tilääni* by Aro, E.:

1. Coincident pair techniques (XY)

- Coincident cardioids angled 180° apart
- Coincident cardioids angled 120-135° apart
- Coincident cardioids angled 90° apart
- Blumlein technique
- Hyper cardioids angled 110° apart
- Mid-Side (MS)
- Double MS technique

2. Spaced pair techniques (AB)

- Omnis spaced 3 feet apart
- Omnis spaced 10 feet apart
- Three omnis spaced 5 feet apart (10 feet end to end)
- Decca tree

3. Near-coincident pair techniques

- The ORTF system
- The DIN System
- The NOS system
- CAP (Common acoustic point)

4. Baffled-omni pair techniques

- Sphere microphone, SASS-P MKII
- Optimal signal or Jecklin Disk

I also found this diagram, where the stereo techniques are compared. It might help you to find the one you might want to try out.

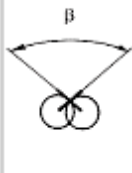
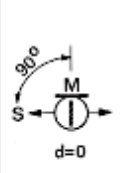
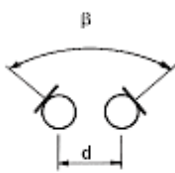
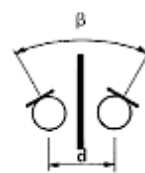
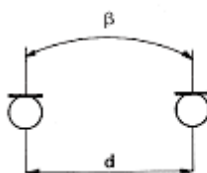
Stereo recording principle	coincident microphone placement		level differences + minor arrival-time differences	microphones separated by an acoustically opaque object	major arrival-time differences
Name	X/Y	M/S	ORTF (for example)	Jecklin disk (for ex.)	A/B
Geometry					
Distance (d) between microphones	0 cm usually vertically aligned		5 cm – 30 cm distance and angle are interdependent	depends on the object between them	40 cm – 80 cm or greater (up to several meters)
Angle between the main axes of the microphones	70° – 180°	90°	0° – 180°	typically 20°	0° – 90°
Acoustic operating principle of the microphone	pressure-gradient transducer (e.g. SCHOEPS cardioid MK 4 or CCM 4)			usually pressure transducers* (e.g. SCHOEPS MK 25 or CCM 25)	
Sonic impression	clean, clear, often bright			big, spacious; especially good low-frequency reproduction when omnidirectional condenser microphones are used	
Spaciousness	often rather limited	satisfactory	good	very good	
Localization	potentially very good, except that the center of the stereo image can be over-emphasized (not a problem with figure 8s)	good	adequate	indistinct (potentially unstable)	
* These recording methods can also employ pressure gradient microphones, though this is not often done.			**The appropriate angle between microphones depends on their directional pattern and the recording angle (the range within which the sound sources should be placed, as "seen" by the microphone.)		

Figure 6. Overview of stereophonic recording techniques (Schoeps. 2008a).

I will present more details about the techniques that are most used with choir recordings, and which are familiar to me as well, in the following chapters. The most popular are XY, AB, ORTF, and the Decca Tree. They use both cardioid and omni-directional mics.

3.7.1.1 Spaced Microphone Pair (AB)

The AB stereo technique is used, when the engineer wants more sound from the space. This technique is used with both omni and cardioid microphones. Omni microphones are the most popular ones used with the AB, especially in classical recordings.

In AB positioning there are two same kinds of microphones that are quite far away from each other, when compared to the distance of human ears. The distance of the microphones is about 30 cm to several metres. (Aro, E. 2006, 119.)

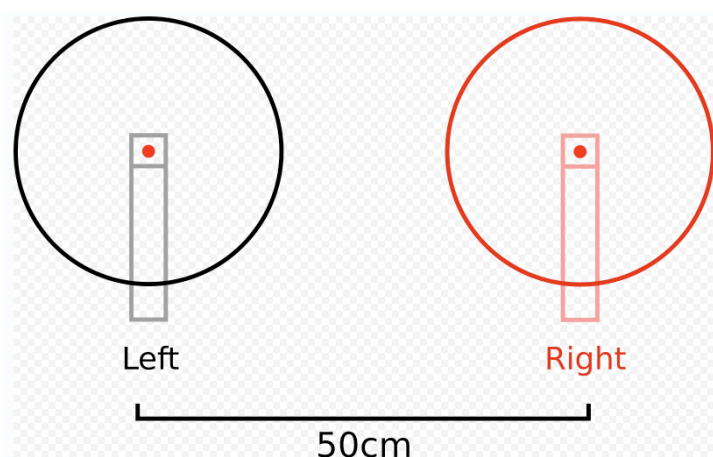


Figure 7. AB

Spaced microphones, however, give a “warm” sense of ambience, in which the concert-hall reverb seems to surround the instruments and, sometimes, the listener. Here’s why: the two channels of recorded reverb are incoherent- that is, they have random phase relationships. Incoherent signals from stereo speakers sound diffuse and spacious. Since spaced mics pick up reverb incoherently, it sounds diffuse and spacious. The simulated spaciousness caused by the phasiness is not necessarily realistic, but it is pleasing to many listeners. (Bartlett, B. & Bartlett, J. 2007, 114.)

“I use the traditional technique, the spaced microphone technique. But the mics need to be wider than 30 cm, otherwise you will have phase issues” (Ari Koivumäki, an Audio Engineer, Interviewed 4th of March 2008) I also prefer the AB space microphone technique, I always use it at least with my ambience microphone pair. Also, I prefer omnis on the AB, because they have a deeper bass than a uni-condenser microphone. Spaced-pair miking is also a good choice, if you want the sonic images to be diffuse or blended, instead of sharply focused.

3.7.1.2 Coincident Pair (XY)

With this method (also called XY), you mount two directional mics with grilles touching, diaphragms one above the other, and angled apart. For example, mount two cardioid mics with one grille above the other, and angle them 120° apart. You can use other patterns too: supercardioid, hypercardioid or bidirectional. The wider the angle between mics the wider the stereo spread. (Bartlett, B. & Bartlett, J. 2007, 110.)

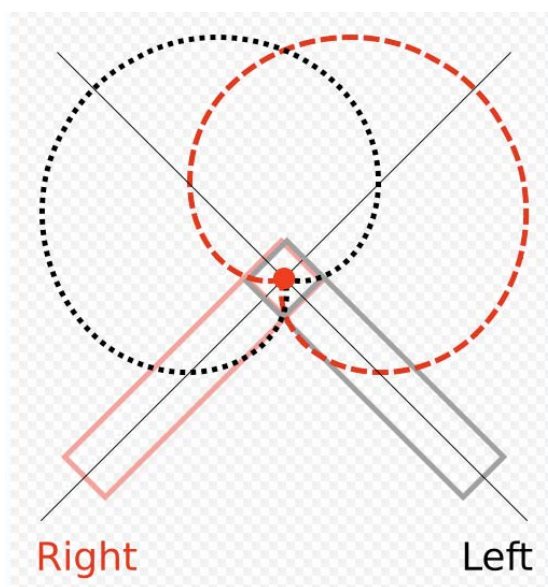


Figure 8. XY

This XY technique is based on the fact that it produces the same signal from each microphone. When you monitor the microphones, the same signal comes out of each speaker. Because the signals are identical, it produces a phantom image in the centre of the speaker, and you are able to hear the centre instruments in the centre. All the most important sound sources in the middle are located on the microphones as off-axis.

The stereo impression made by the XY-pair is based on the intensity differences between the two channels. There are no time or phase issues/differences because the capsules of the microphones are so close to each other. (Aro, E. 2006, 121.)

I know engineers who use this technique a lot, and you are able to vary it a lot with the angles and distance as well. I personally do not use it that often because of the off-axis method that it is using, because it might cause problems with the accuracy in the centre image, and have the edges of the image sharper than the centre.

3.7.1.3 Decca Tree

In Decca Tree positioning, there are three omni microphones in the corners of a triangle. The triangle base is 135 cm (4'6") long, and the height of the triangle is 75 cm (2'6"). (Aro, E. 2006, 120.)

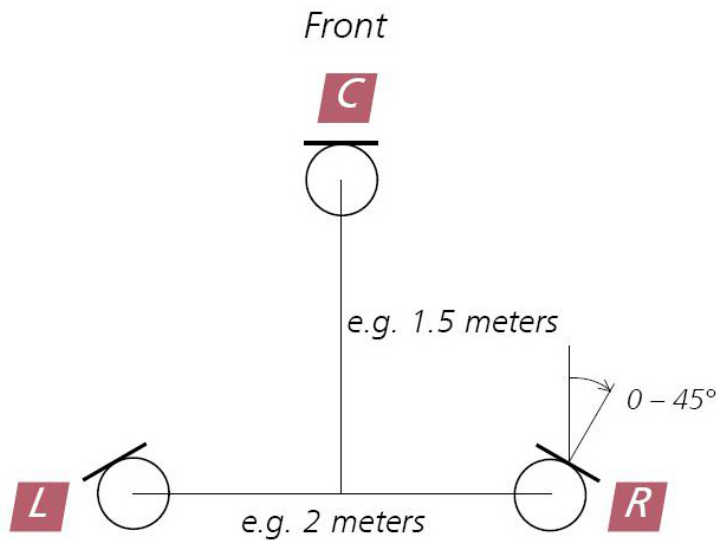


Figure 9. Decca Tree

With the Decca Tree, you are able to adjust the distances between the microphones, as long as the centre microphone is closer to the sound source than the side microphones. These microphones are panned left-centre-right, and the side microphones are angled a little away from the centre, so that it brings more brightness to the sides. With this technique, you can also use two other omni microphones at the edges as outriggers.

Decca Tree technique is more accurate because of the centre microphone than the AB technique. Because of the long distances with the microphones and the omni pattern, the spaciousness is overwhelming. (Aro, E. 2006, 120.)

The positioning of the microphones depends a lot on the acoustics of the recording venue. Decca Tree (also the surround version) is a very useful positioning technique. (Jouko Ahera, an Audio Engineer, Interviewed 12th of April 2008)

I have only used the Decca Tree with small ensembles, and it made the ensemble have a lot more body and intimacy. I am hoping to try it out with large choirs, and with the additional pair of flanking microphones (the outriggers).

3.7.1.4 ORTF, DIN and NOS

The listening tests reveal that the 110° angled, 17-cm (6,7-inch) spaced cardioid array (the ORTF system) and the 90° angled, 8-inch (20cm) spaced cardioid array (the DIN system) tend to provide accurate localization. According to a listening test conducted by Carl Ceoen (1972), the ORTF system was preferred over several other stereo miking techniques. It provided the best overall compromise of localization accuracy, image sharpness, an even balance across the stage, and ambient warmth. (Bartlett, B. & Bartlett, J. 2007, 216-218.)

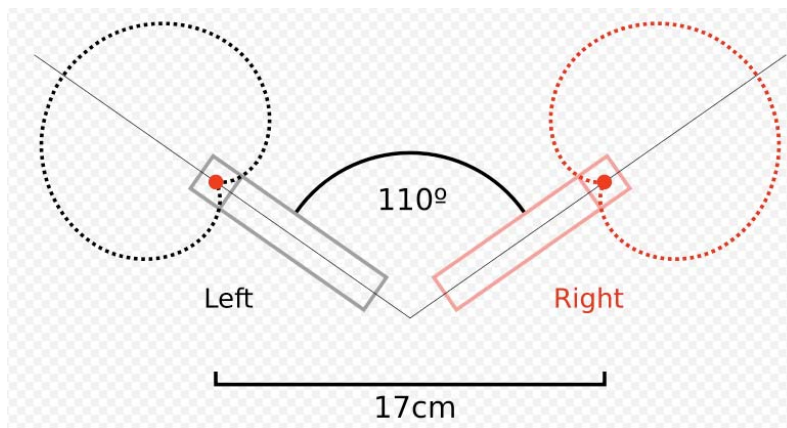


Figure 10. The ORTF (Office de Radiodiffusion Television Française) system

I ended up using the ORTF technique for the main pair of the choir recording. The omni microphones did not give me the space that was desired, instead it made the stereo image very messy a little hollow. Because of this, I ended up using a clearer and brighter ORTF technique, because I think that my microphone Schoeps Cmc with Mk4- capsule is one of the best cardioid microphones for the ORTF technique. With the stereo pair, I used the Oktava microphones at the back of the space as ambient microphones with AB technique. The Akg 414 microphone pair I used as spot and also for solo microphones. (Murtoniemi, M. 2005, 37.)

The NOS system uses two cardioids angled 90° apart and spaced 30 cm (11,8 inches) horizontally. Since the spacing of the NOS system exceeds the 90° angled, 8-inch-spaced array in the listening test, we could expect it to have a slightly wider stereo spread for halfway-left and –right instruments. (Bartlett, B. & Bartlett, J. 2007, 218.)

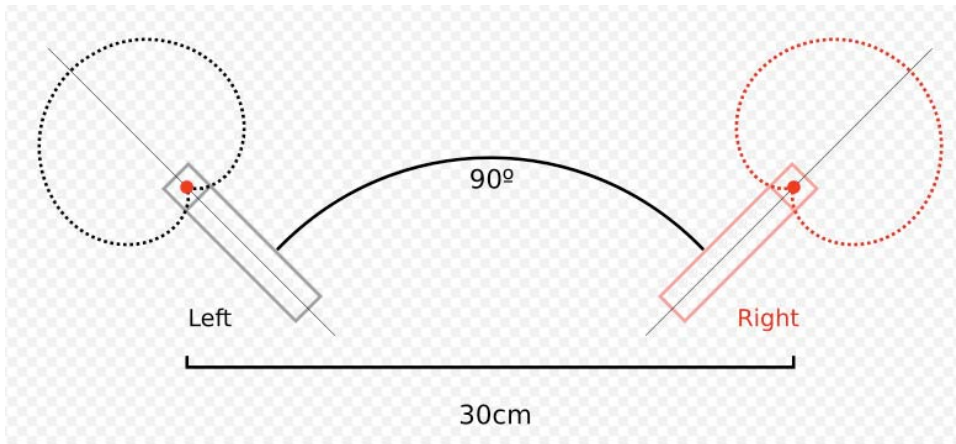


Figure 11. The NOS (Nederlandse Omroep Stichting) system

I tend to use all of these techniques depending on the choir, and the positioning of the choir. But, I mainly use the NOS or DIN systems, because they give me a little wider stereo image. In my opinion, this has been a good way to record, because I feel it gives me everything that I need to get a nicely spacious and warm acoustics, and is still bright and accurate with no muddy bass. Even though I do like omni microphones, I have still gone more towards the accurate and bright cardioid microphones.

3.7.1.5 Stereo Spread

Concentrate on the stereo spread. If the monitored spread is too narrow it means that the mics are angled or spaced too close together. Increase the angle or spacing between mics until localization is accurate. Note: Increasing the angle between mics will make the instruments sound farther away; increasing the spacing will not. (Bartlett, B. & Bartlett, J. 2007, 130.)

It depends on how you want your stereo image to be, but remember that if you space your microphones too close together, you get a narrow stage width, and if you space or angle the microphones too far apart, you hear exaggerated separation. In other words, you are missing your centre in the stereo image.

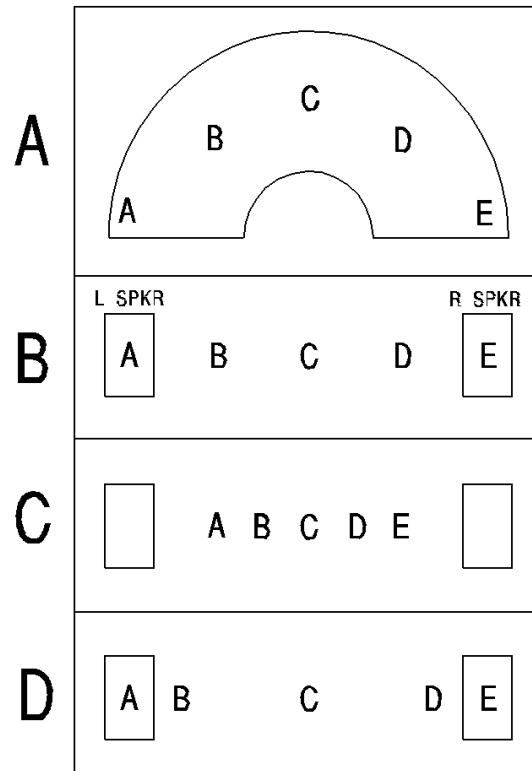


Figure 12. Stereo Localization effects: (a) orchestra instrument locations (top view); (b) images accurately localized between speakers (the listener's perception); (c) narrow stage effect; and (d) exaggerated separation effect (Bartlett, B. & Bartlett, J. 2007, 159).

There are two important things when positioning microphones. First one would be capturing the panorama of the group, the left and right distance and also then determining how much reverb I want from the natural environment. So that would be proximity, getting the closeness to out and reverberant ratio right. I prefer to be a little closer to the ensemble initially so that I don't have to worry about there being too much reverb. There is always a little less reverb than maybe optimum. I tend to record closer to the ensemble generally because I like to hear clarity. The ambient characteristic of the space and the panorama, the two of them work together. (Mark Corwin, an Audio engineer and a Professor, Interviewed 19th of March 2007)

In order to keep your stereo sound good and your stereo spread perfect, you need to avoid these problems, and pay attention to them one way or another: distortion in microphone signal; too dead-sounding sound with not enough reverberation; too detailed, close or edgy sound; too distant sound with too much reverberation; narrow stereo spread; excessive separation with a hole in the middle, or the soloist is moving too much; poorly focused

images; images have shifted to one side, meaning that your left-right balance is faulty, lacking depth or spaciousness; the early reflections are coming out too loud; bad balance or tonal balance; and muddy bass.

These are all things that you can change by changing the angle or height of your microphones, or by moving and placing your microphones closer to or further from the performers.

3.7.2 Surround Techniques

Recording surround has even more challenges than doing a normal stereo recording. To the surround sound, you need more microphones than to stereo recording. To create a working surround microphone setup, you need at least 4 to 5 microphones. The techniques are a little different than stereo techniques. You need two extra microphones for rear microphones behind the left-right array, and a centre microphone between the main pair, to feed the centre channel. In acoustic music recording you do not need the subwoofer, so these are 5.0 or 4.0 recording techniques.

The more the microphones, the more the problems. Already, with more than two microphones, you might get some phase issues, sound cancellation, and sound coloration. The closer the microphones are, the narrower the polar patterns should be, and when recording with omnis you should have the microphones far away from each other. When doing so, it prevents the pick up areas of the microphones from crossing.

Recording in surround has two main principles; so called one spot miking technique that is compiled from one cramped microphone group, and from a so-called separated microphone technique, where the microphones have longer distances to each other (Aro, E. 2006, 125).

You should think of the microphones as pairs, front and back pairs, which will help you to mix your recording afterwards. Also, each pair should be the same microphone, or a matched pair, and the pairs should also be placed symmetrically toward the centerline.

There are a lot of different surround recording techniques, but there are no new standards yet, and because of this the surround recording is open for experimenting and suggestions (Aro, E. 2006, 125).

The surround recording techniques vary a lot, and here are the ones that I found:

1. Separate microphone techniques

- Decca Tree
- Fukada Tree (or DMP Method)
- Hamasaki
- ESE
- Delos VR2 Surround Miking Method
- NHK Method
- Woszczyk Technique
- Polyhymnia Pentagon
- Omni Curtain

2. Near-coincident microphone techniques

- INA-5 (Ideale Nieren-Anordnung)
- OCT
- IRT Atmo-cross or SAM (Surround Ambience Microphone Array)
- TSRS (Williams Five Cardioid Mic Array)
- Corey/Martin
- Double –MS
- Mike Sokol's FLuRB Array
- Slotte method


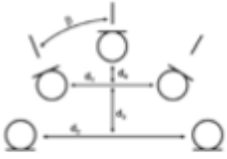

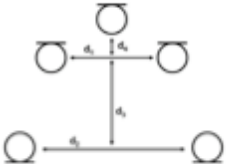
3. Dummy Head combinations

- Schoeps Surround Sphere (KFM 360 Surround Miking System)
- John Klepko method
- MS- Dummy head combination
- Holophone

4. Surround microphones

- SoundField 5.1 Microphone system

I also found this diagram, where the surround systems are compared. It might help you to find the one you might want to try out.

Category of microphone arrangement →	Coincident placement	Near-coincident placement	Microphones separated by an acoustic baffle	Spaced microphones
Principle by which the stereo effect is obtained	level differences	level plus minor arrival-time differences	frequency-dependent level and time differences	arrival-time differences primarily
Typical setups	Double M/S, First-order Ambisonics	OCT Surround, MMAD, INA 5, IRT Cross	KFM 360 system	Decca Tree, Omni Curtain, Polyhymnia Array, Hamasaki Square
Geometry				
Distance between microphones	0 cm	15 - 100 cm	15 - 20 cm	100 - 500 cm
Microphone types used	pressure-gradient transducers (e.g. SCHOEPS cardioid CCM/MK 4, supercardioid CCM/MK 41, figure-8 CCM/MK 8)		SCHOEPS KFM 360/ DSP-4 KFM 360	mainly pressure transducers (e.g. SCHOEPS CCM/MK 2H), also possible with cardioids or wide cardioids
Sonic impression (depending on which microphones are used)	clean, clear, often bright	natural, clean, clear	natural	spacious
			full low-frequency reproduction when omnidirectional microphones are used	
Spaciousness*	often limited; depends on M/S decoding parameters	natural, transparent, good depth	natural	good, enhanced (can become exaggerated)
Localization*	good; depends on decoding parameters	very good	generally fairly good	somewhat indistinct
Size of listening area*	small; better when additional delay is employed	large	rather large	depends on microphone distances
Envelopment*	limited; better when supplemented by an A/B pair	good envelopment possible		
Downmix compatibility	two-channel and/or mono (!)	two-channel compatibility can be good if considered in the array design (e.g. OCT 2)	perfect	potentially good, but this requirement must be taken into account and the setup tested for this purpose

* The statements here are necessarily rather general. The properties of the recording often depend on various parameters which cannot be covered in detail in this list. These properties can furthermore be varied by combining various aspects of different setups.

Figure 13. Overview of surround recording methods. (Schoeps. 2008b, 14.)

This list should be considered as a snapshot of current techniques for surround recording. It may be subject to change. It is not intended to create dogmas or "untouchable" recipes for surround recording. The recording engineer and producer are needed more than ever to listen, consider and adjust the results obtained. (Schoeps. 2008b, 14.)

In the following chapters, I will present more details about the techniques that I think are the most used ones with choir recordings, and which are familiar to me, or which I have used before.

3.7.2.1 OCT (Optimized Cardioid Triangle)

"OCT Surround" is a well-proven microphone setup for discrete 5-channel surround recording. The OCT front system is supplemented by two cardioids which face rearward to avoid picking up direct sound. Time-of-arrival and level differences between each side's cardioid and hypercardioid pair produce a stereophonic representation of lateral sounds to complement the front stereo image. Lateral reflections, which are important for the perception of the room, are reproduced correctly; this produces a convincing spatial perspective. In playback, the "sweet spot" is large, allowing listeners to move around without the stereo image collapsing. (Schoeps. 2008b, 4.)

This is a surround system developed by Günther Theile and Helmut Wittek. The distance between the left and right microphones is about 60-80 cm, and the centre microphone is about 8 cm to the front from them. Because the left and the rear left, and the right and the rear right are side by side as omni and supercardioid, it improves the pick up of low frequencies. With the omni microphones you filter everything over 100 Hz, and with the supercardioid you filter everything under 100 Hz (Aro, E. 2006, 131).

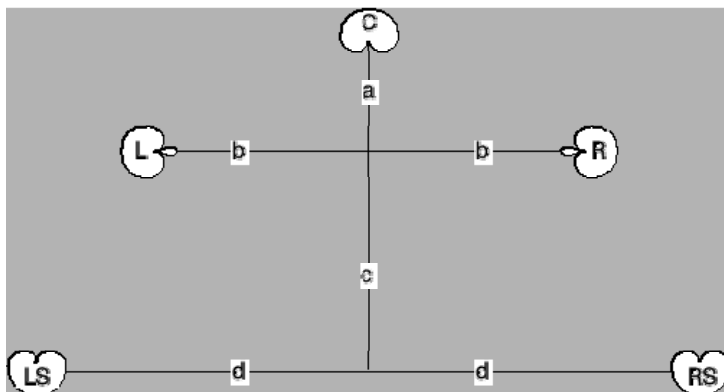


Figure 14. OCT surround:
 $a = 8 \text{ cm}$, $b = 40 - 90 \text{ cm}$,
 $c = 40 \text{ cm}$, $d = 10 - 100 \text{ cm}$
 (Martin, G. 2006a).

3.7.2.2 Decca Tree and Fukada Tree

Music recording engineer Lars Christensen of the Danish Radio has used modified Decca Tree for recording classical music. He has added two rear channel microphones to it. [...] For the rear channels, Christensen is using either a ORTF pair with two cardioid microphones in 110 degree angle toward each other, distance 17 cm, or an AB-pair with two cardioid microphones pointing to the back, distance about 2 metres. Between the front and rear microphones, the distance needs to be long enough, in regular concert halls around 8 to 10 metres. (Aro, E. 2006, 127.)

For multichannel recording the left, center and right microphone signals are recorded discretely. Surround signals can be obtained either from two additional microphones at a moderate distance from the main microphones, or a setup such as the Hamasaki square or the IRT cross can be used. (Schoeps. 2008b, 12.)

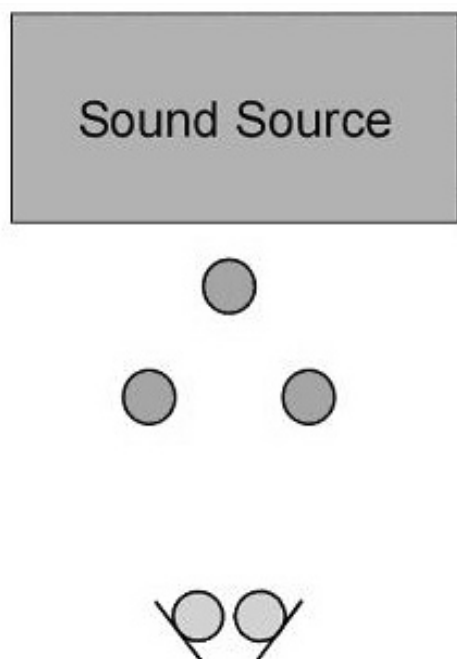


Figure 15. Decca Tree surround

Since the Decca Tree technique evolved via trial and error rather than being designed on any theoretical basis, it is no surprise that many variations of it exist. Some of these have names of their own, such as the "Polyhymnia Pentagon" (for surround) or the "Omni curtain" (for surround or for two-channel stereo); these are based on the same principle as the Decca Tree. In addition, microphones of other directional patterns are often used in setups with similar geometry, as in the "Fukada Tree" arrangement for surround. (Schoeps. 2008b, 13.)

The Fukada Tree technique is a modification of the Decca Tree recording technique. The Fukada Tree replaces the omni-directional microphones of the Decca Tree with cardioid directivity pattern microphones in order to reduce the non-direct sound energy in the front channels. The configuration of this technique is shown in Figure 16.

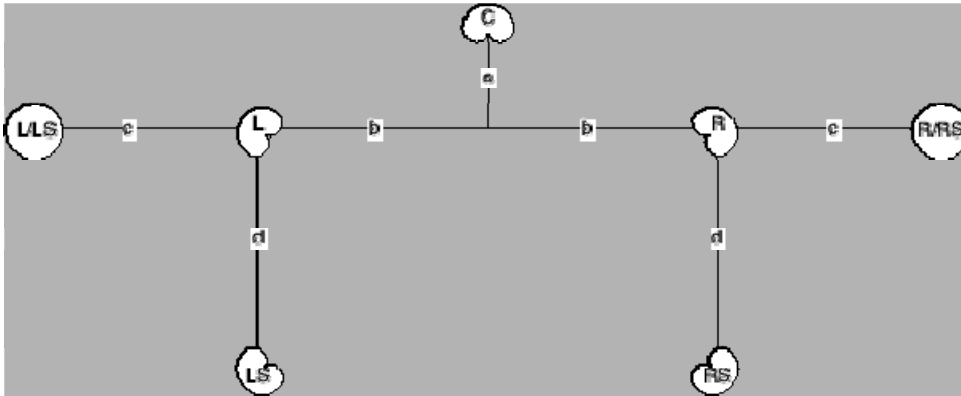


Figure 16. Fukada Tree: $a = b = c = 1$ to 1.5 m, $d = 0$ to 2 m, L/R angle = 110 to 130 , LS/RS angle = 60 to 90 (Martin, G. 2006b).

The cardioids are angled between $\pm 130^\circ$ and $\pm 150^\circ$ relative to the centre. Each microphone is evenly spaced from the centre point at about 1 to 1.5 metres. Two omni outrigger mics are added to the array, in line with the L/R mics and a similar distance from their corresponding cardioid partners. (Whiston, B. 2008, 3.)

Two cardioid microphones are added to cover the rear, in line with the forward-facing L/R microphones, coincidentally if required but no more than 2 metres behind them, and at an angle of between $\pm 60^\circ$ and $\pm 90^\circ$. (Whiston, B. 2008, 3.)

3.7.2.3 *Burmajster Array*

Based on extensive listening tests, this array was invented by Chris Burmajster of Innocent Ear Ltd. It includes an ORTF pair for left- and right-front channels, a center mic, and two rear-facing cardioids angled 90° for the left- and right-rear channels. The mics are mounted on the metal bar shown in Figure 17. According to the inventor, this arrangement provides solid central imaging. The rear ambience channels sound coherent with the front channels, rather than “disjointed” as can happen with mics far back in the hall. Details are at <http://homepage.ntlworld.com/chris.burmajster>. (Bartlett, B. & Bartlett, J. 2007, 152.)

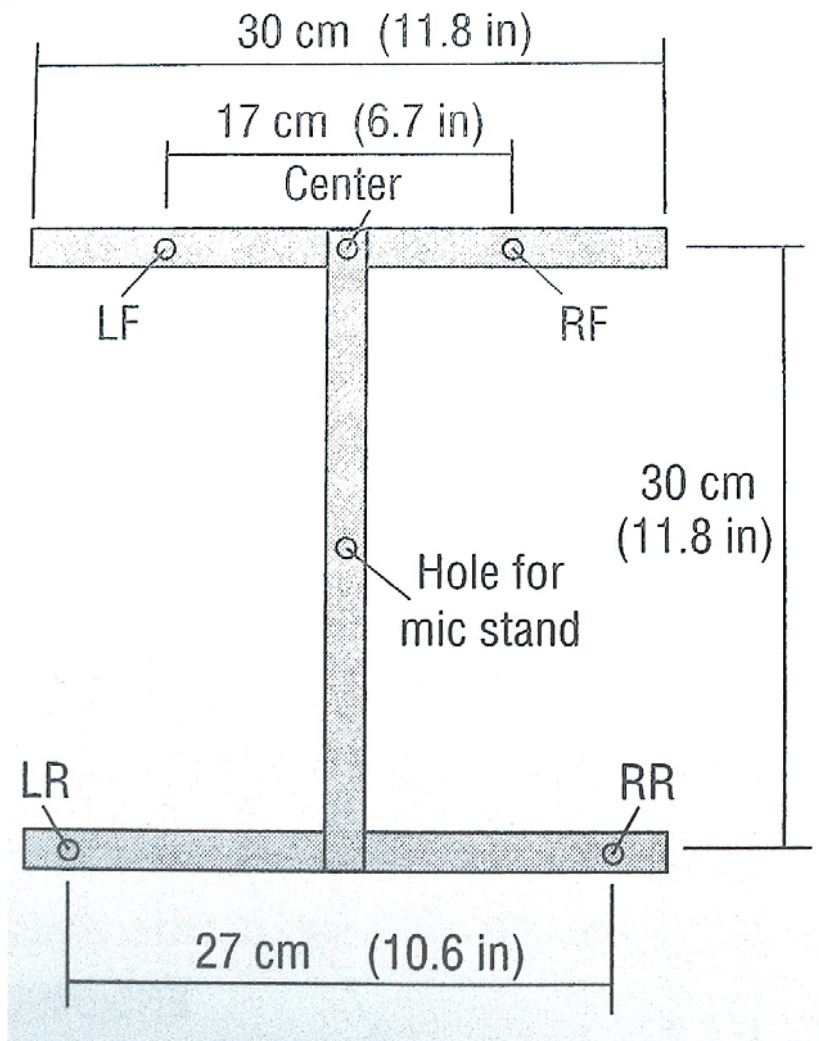


Figure 17. Chirs Mumajster array (Bartlett, B. & Bartlett, J. 2007, 152).

I have used this array with this kind of a metal bar. You are able to build this kind of a bar yourself too. It is easy to carry on to locations, and easy to setup to just one stand. Just make sure that your stand can hold the weight of all the five microphones. In my opinion, this surround system has sounded good, and I will most likely use it again in the future, because it creates a natural sounding surround of the recorded space.

3.7.3 Solo and Spot (Side) Microphones

Microphones for the soloists, or a microphone for the piano, or an instrument performing with the choir are different things. They normally need their own microphones but I do know engineers who do not want to put a microphone even for the accompanying piano. I always like to record the accompanying piano stereo, because with mono it has no space at all. I do not like to hear the piano in its own particular small spot in the stereo image with a large choir. I want to give it at least a little bit more space in the stereo image.

You need to be able to effectively balance the accompaniment with the choir and so I tend to mic up the piano and record it onto its own track. That way you can get the best positions of the choir and the piano and if necessary bring up the level of the piano at the mix back in the studio. (Rowley, J. 2006.)

Most frequently the piano is either in a half stick or all the way down or maybe on a small block so the clarity of the piano is the problem, getting it nice and bright. (Mark Corwin, an Audio Engineer and a Professor, Interviewed 19th of March 2007)

Solo microphones are sometimes necessary, but sometimes you can replace them with bringing the singer in front of the choir, and closer in the stereo image. Sometimes the choir does not want the soloist to be any louder than the choir, and the soloist is placed within the choir. These are all matters of taste, and depend on the style of the music. But, I do like to place a solo microphone, just in case so you are able to bring the solo up, if needed. Also, how far away exactly the microphones should be placed from the soloist is not that important to me, as long as the soloist sings towards the microphone.

Sometimes a soloist plays in front of the orchestra. You have to capture a tasteful balance between the soloist and the ensemble. That is, the main stereo pair should be placed so that relative loudness of the soloist and the accompaniment is musically appropriate. If the soloist is too loud relative to the orchestra (as heard on headphones or loudspeakers) raise the mics. If the soloist is too quiet, lower the mics. You may want to add a spot mic (accent mic) about 3 feet from the soloist and mix it with the other microphones. Take care that the soloist appears at the proper depth relative to the orchestra. (Bartlett, B. & Bartlett, J. 2007, 132.)

There are also spot microphones, but mainly with orchestra recordings. Spot microphones with choir can be thought of as side microphones (meaning that it is a side microphone pair left-right) that are supporting the actual stereo image. Basically, this pair is an AB pair, the

other one on the left side of the choir, and the other on the right side of the choir. But if you have individual spot microphones, you should pan them into the stereo image to the same places as they are in the recording space. Also, they are put to a relatively low level compared to the main stereo pair. Here is a good tip of how to find the right places: Using the mute switches on your mixing console, alternately monitor the main pair and each spot mic to compare image positions (Bartlett, B. & Bartlett, J. 2007, 133).

A choir that sings behind the orchestra can be miked separately with two to four cardioids. You might place the choir in the audience area facing the orchestra, and mike the choir. (Bartlett, B. & Bartlett, J. 2007, 133.)

Also, the situation is different, when the choir is singing with an orchestra. Depending on where the orchestra is playing, of course, but normally it is in front of the choir. There might not be enough space to put another stereo pair in front of the choir as well, so you might be forced to mike the choir with spot microphones and the AB side pair. I would place two cardioids for the choir, or maybe three as left-centre-right, depending on how wide the choir is situated behind the orchestra. The cardioids are better, because they are directional and will mainly take the choir, and not the orchestra, unlike omnis that take sound everywhere around them.

I developed a new idea how to do editing easier for choir music. I call it the editing microphone, which I place very close, for example to the sopranos. This microphone is supposed to pick up the lyrics clearly, and according to those waveforms, it is easier for me to do the editing graphically in a sequencer program. (Murtoniemi, M. 2005, 54.)

I have not used this “editing microphone” technique, but it might help you, or then again it might give you even more work. Of course, it will take more space on your hard drive, and also you will have a one more microphone to observe. I have always managed to do editing without it, so I personally do not find any need for it.

3.8 The Actual Recording Situation

When the actual recording situation comes, not only is it important to concentrate on to your own work, but it is also important that the atmosphere during the entire recording process is relaxed. However, focus on the main thing; the music.

The listener cannot see and know how the recording is done, while holding the recording in his hand. What you can hear, matters. That is why you want to finish all the details as perfectly as you can during the recording situation. (Koivusalo, M. SULASOL 1/00 III.)

The main important things are to be confident in what you do, have everything planned well, everything ready to start, and behave like a professional.

3.8.1 What Is Expected from the Audio Engineer

In order to successfully carry out the recording situation, it is important to get along with everyone in the project. You have to trust that everyone will do their job, and remember that it is a team work, and as an engineer you are not responsible for everything. This is something that the engineers tend to forget, and try to do more than is required. Also, plan your duties, so that you are not doing unnecessary things.

In all the relationships between the recording team, it is important that all the persons involved have respect to one another and have a trustful relationship. When recording, they have to be professionals in their own field, and equally acclaimed partners. Working together is easiest when the choir, the choir director, the producer and the engineer already know each other, and the trust is there already before the project. I have been lucky to able to work with people and choirs that I already know, and that are familiar to me. (Titta Lampela, a Producer, Interviewed 13th of April 2008.)

The role of the audio engineer is very central in making a recording, because he/she is in charge of the technical quality, and is trying to carry out technically the vision that the producer has. When there is no producer, the responsibility is even bigger. It is really challenging for the engineer to make everything happen technically, and also to be able to make the anticipations of the producer come true. The audio engineer has to have a solid vision about his/her own abilities and opportunities in order to affect to the sound of the recording already at the recording situation, not just at the post-production.

The audio engineer has to know how to do his job. In a way you have to be a professional, so that you are able to resolve and produce the sound the way that is familiar to the choir director. He also has to be an easygoing person with social skills, even if the producer is the one keeping the most contact. The engineer has to also be

able to stick with the schedule that everyone has agreed upon. (Kari Turunen, a Choir Director, Interviewed 9th of April 2008.)

You have to be the ears for the choir director, especially if there is no producer in the project. You have to have the courage to say that everything is not correct, or the take was not good, or something else. There is no benefit for anyone if you are too shy to open your mouth. I know it is hard, because the recording situations with classical music tend to be very conservative situations, and you have to select your words carefully.

There are different phases in the work of the audio engineer that demand planning, carrying out, evaluation, and suggestions to make it better (Murtoniemi, M. 2005, 61).

It would be good to get some feedback from the engineer about the pitch and the tune of the songs immediately, because you can not notice everything while conducting the choir. He could let me know right away, when he notices something going wrong. He could then stop the recording, so that there would not be too many false and unnecessary takes. I would also hope that the engineer would make it possible for the choir to listen back the takes, and not just for the choir director, because it would motivate the choir rather than always waiting and finally seeing the choir director coming back from listening and shaking his head. (Pekka Nikula, a Choir Director, Interviewed 15th of April 2008.)

I would still emphasize the importance of courage to do and say things. Also, I think that to avoid awkward situations, and moments where you do not know what to do, always discuss with the people who you are working with, what they are expecting from you, and how they want to proceed with certain things and situations. Of course, it is hard to predict how the recording situation goes, but you should never just wait for them to come to you, you should also go to them.

One of the most important characteristics of the audio engineer is to be able to modify to different situations and accept suggestions about changing things in order to get the best outcome. This is when the creativity of the engineer comes out. You are able to get there, when you have the technical skills and confidence of doing your work. Also, you have to dare to throw yourself to the demands of the recording situation and have the courage to carry out sometimes a little different and unusual experimentations. (Murtoniemi, M. 2005, 51.)

3.8.2 Setting up and the Sound Check

I would recommend giving more time to the setting up and for the sound check. I like to work in such a way that everything is ready, and when the actual recording starts, I can focus on something else than to the technology that much. An hour for setting up is definitely not enough to me, if I am working alone, because I like to take it easy and not stress myself. I like to place my microphones and cables peacefully and accurately, even though I will change the microphone placing during the sound check. I also will try to get the choir director and the producer to understand the importance of the sound check. Although you have to be careful not to tire the choir. When you do your job with care, it always pays off.

I should strive to the situation in the future, where I am able to set up without any hurry. It is a completely different feeling to start a recording, when you know that everything works, because the gear is ready and tried out. I feel that this gives out a professional impression. I have been a choir singer before in a recording situation, and been forced to sit around and wait even three hours for the engineer to set up. He has not been hired since. (Murtoniemi, M. 2005, 35.)

When the sound check is ready to start, and the choir members have arrived, and you have all your gear working and ready, the choir normally starts practising, and to open their voice. I also tend to record the practice sessions in order to hear how the microphones sound like. It helps me to listen to which positioning was the best, if I need to go back to some earlier positioning. I always start my sound check with the main stereo pair, and I know many engineers tend to do it so as well.

In a recording situation, I place the microphones carefully and do the first listening. Then I correct them according to how requested, and how the producer, and choir director wants the choir to sound like. Also, the choir director will instruct the choir members. I will try to work very studiously, so that the choir will not get tired before the perfect timbre will be found. I am always careful about my communication, so that I do not want to ruin the good atmosphere by being self-important. For example after every take when the choir director asks how the take was, I think carefully what to answer, including the way I say it. (Ari Koivumäki, an Audio Engineer, Interviewed 4th of March 2008.)

We'll do a short recording of their opening work. I'll have them come upstairs, the director, or producer, or choir director, and listen to it, and I'll ask them is it too dry is it too wet, are you picking up enough of the basses, enough of the sopranos or altos or too much sopranos the accompanying instrument, is it piano, is there enough of the piano, can you hear enough clarity from that so you understand what is going on, does it have to be further back in the mix? (Mark Corwin, an Audio Engineer and a Professor, Interviewed 19th of March 2007)

Normally, after the first takes, the choir director and the producer listen how it sounds like, and they give you suggestions how to maybe change it, or what they would want more or less. They will also decide whether the choir's positioning needs to be changed or not.

Ask the conductor to play the loudest part of the composition, and set the recording level for the desired meter reading. A typical recording level is -6dB maximum on a peak-reading meter for a digital recorder. The level can go up to 0 dB maximum without distortion, but aiming for -6dB allows for surprises. (Bartlett, B. & Bartlett, J. 2007, 134.)

The levels should not be too low, or too high and peaking. Otherwise, it will give you more work to do afterwards. Also, normalizing afterwards, if the level is too low, will always bring all the hiss and noise sounds up as well, which you did not hear during the recording situation. After you have found your levels, you should not touch them again, if you do, you will end up having changes in the volume, and it will affect your editing process. Also, it will not give a coherent entirety, if other parts or songs are recorded with different levels than others.

In classical music recording you rarely touch the desk again once the right balance has been achieved, because any alterations to the sound between takes can make editing impossible. (Robjohns, H. 1999)

3.8.3 Communication and Behaviour

Stay out of the way and let [a choir] communicate (Fuston, L. according Weiss, D. 2006, 36).

The audio engineer is considered to be as invisible as possible. I have noticed this all around. I have been told many times that as an audio engineer you can not make noise and draw attention to yourself. This was explained to me based on the fact that because the recording situation is not about you, it is about the artist and for the artist. You are just a worker for the

artist. The more humble, the better you are, I have been told in Canada many times, even here in Finland a couple of times. But, I did notice that this is not quite true. As we know, it is the engineer who controls the recording situation and is in charge, especially when it comes to technology and the way the recording sounds like. It is just kept quiet from the artist, so that the artist thinks he is in charge.

The ultimate goal for an audio engineer recording a choir should be his or her own transparency in the process (Weiss, D. 2006, 36).

Theresa Leonard (my mentor in the Banff Centre) always advised me to do the following if I do run into some technical problems during the recording, instead of telling exactly what wire and what equipment is broken or not working, the best way to handle the situation is to be very calm and not alert any panic. Avoid the word panic.

I have always been advised also to tell the artist(s) to take a break. Advise the artist(s) to go to lunch for example, or cigarette break, whatever, and tell how much time you need. This should be explained in a very calm way, and that you are doing your best so that the recording situation can continue as soon as possible.

A long recording process makes your pressure tolerance stronger and teaches you to control stressful situations. If you do not take any breaks your hearing will become slack and will be on trial with long sessions. Regular pauses for dining, getting fluids, fresh air, break exercise, etc, are good for the musicians, producers, and to audio engineers too. (Rantanen, E. 2001, 37.)

If you feel that you can not take it anymore, then you need to suck it up sometimes. You need to control your feelings. If you interrupt the artist(s), they might not get that feeling and thrive again, when interrupted. They might also get annoyed and frustrated, if there are problems with the technology or by the engineer all the time. You need practice and do several recording sessions to be able to control the situations better, and also to manage people better as well.

Naturally, the skills of singing and playing or listening are in the main role when doing a recording. On the other hand, there is also a lot of organising, haste and pressure. Experience in practice will teach you to control these things. Also, the making of the choir recording is a very social process. (Rantanen, E. 2001, 38.)

Even if you have everyone listening back how everything sounds like, be ready for the criticism and to the fact that everyone has their own opinions. You need to be strong in your own opinions and methods, overall you are the professional when it comes to technology, and they are not.

There will be more opinions, when all the musicians, the producer and the engineer all are in the studio at the same time. It is a lot better for the recording when there are less people making the decisions. It is up to the producer to decide how to proceed in the situation. (Rantanen, E. 2001, 35.)

I always try to get everything go smoothly, and it is also my job to build an image that everything is in control, and that I am also a nice person, even though I am behind all the technology. I try to speak in a way that a “normal” person can understand me. I tend to leave professional audio slang away, because they do not understand me otherwise. They have no idea what you are saying, if you are talking to them about polar patterns, or resolutions, or whatever audio talk. As if you were talking a foreign language. Other people tend to have their own golden ways in how to behave during the recording session, so does a recording engineer.

When talking about interaction skills, the positive interaction in everything that the producer/the choir director does influences the learning process and succeeding of the choir, in practices as well as in a recording situation. This means the choice of words at different moments. Sometimes you need to be tough, but with humour and positive attitude you are able to make changes and give criticism without anyone being offended. In a positive atmosphere everyone feels that they are important, and will learn even more challenging tasks. (Rantanen, E. 2001, 35.)

3.8.4 Using the Technology and the Recording Process

How the recording process proceeds depends a lot on the ways and recording habits of the choir director and the producer. It is pretty much always different with different choirs. Sometimes, recording in parts is preferred, but mainly I have noticed that longer takes are preferred. Mistakes are corrected after the long takes, or the entire songs have been completely recorded.

It depends on the choirs, how to work in the recording situations. Sometimes the composition is being recorded with few whole takes, and then decision of a perfect fit from them is finalized at the editing phase. When there is a more difficult composition, you might start to record it straight away in parts. This makes it easy to control the outcome, and staying in the right pitch all the time. In longer takes, the pitch easily starts to drop. (Koivusalo, M. SULASOL 5/99 II.)

I prefer long and peaceful takes. I want to record with the choir without unnecessary retakes. It is better, if we are able to record many hours straight. (Kari Turunen, a Choir Director, Interviewed 9th of April 2008.)

What comes to the actual order of the material that needs to be recorded, it is something that either the producer or the choir director decides. As an engineer, I have never got involved about deciding the order of the material, unless I am also producing the project.

The producer makes a good recording order of the material that can be adjustable during the actual recording before the recordings. For example, the most challenging songs that require most work would be ideal to record during day time when the choir has the best tune; for the evening you could leave the easier songs. (Rantanen, E. 2001, 33.)

There are a lot of opinions on the methods of using your gear and software. Some engineers prefer to do a lot of edits, or some will let the artist to play/sing as much as needed without stopping the recording, or some will try to do every take/part as a different cut. I think this is something that you need to figure out, and find out what is the best and the fastest way for you to work with the software you are using. I do not think that there is one perfect way. I only think the best way for you is that you know where the files have been saved, and that you also know which files are which takes and which songs/parts. Naming is one of the most important things to do. I also try to avoid recording useless and empty takes / silence.

One good thing that I have noticed as well while recording, is that if you are able to get simultaneously, with your multitrack recording, a stereo recording for the producer for his/her listening, you save up a lot of time. The few problems with this are that you have to take care of two recording programs or equipments at the same time, and that the takes need to be exactly the same for the producer as they are in your main session. The order has to be the same all the time, and the naming the same as in your main session files.

You could record the cd for the producer of all the material simultaneously at the recording situation as stereo. After the recording situation you would be able to give the material to the producer immediately for listening. (Murtoniemi, M. 2005, 54.)

Something that I have tried only few times, is the external reverb. It made my listening a lot easier, when figuring out how the outcome would sound like. This has not become a habit to me, because I have learned to hear the reverb that I am able to make afterwards, while setting up microphones and doing the sound check. I also think that this is something that I will decide based on the fact that I will get a nice pick up, and I also just take care of the fact that my pick up is never too reverberant. I always try to get the best reverb of the space, if I like the reverb of the space. If I do not like it, I tend to record a little dryer version and add the reverb later.

I also admit that if necessary, I will add reverb on the main pair with a separate reverb generator. I also compress the signal before it so that it won't peak. (Ari Koivumäki, an Audio Engineer, Interviewed 4th of March 2008.)

It would have been important to have had some kind of a separate reverb generator in the sound check. With the reverb, I could have been able to give the artistic producer an example of what it is possible to do with the sound afterwards, when mixing. Now that I did not have it, the sound was very dry, and I thought that it was even too dry for choir music. (Murtoniemi, M. 2005, 38.)

3.8.5 Musical Notes and Notation

I personally will concentrate better on the sound quality if I read the notes, and this way I will pay attention to each sound more, and the timbre as well. This will help for you too to find the best takes, and you know exactly how the recording is going. Some engineers will not listen to everything at all. They put their headphones on the table, or/and do something else during the recording. I could not do that, even if there was a producer who would be listening all the time, because then I cannot hear if something critical happens there, or some extra sounds appear that do not belong there. Also, if you have not been listening, what do you say when the choir director asks you, if the take was the best so far, or how it went. You are the one getting paid especially for listening, no matter what.

When I work with the engineer, it normally goes the way that the engineer writes down the technical things about the recording, he also takes care of the fact that the tape is rolling. The engineer controls the sound quality all times. (Titta Lampela, a Producer, Interviewed 13th of April 2008.)

It depends on the difficulty of the scores, but it is great if I can concentrate on them during the balance (Amandine Pras, a Producer and an Audio Engineer, Interviewed 16th of April 2008).

It is good to find out before starting to record how the producer works, and how he/she is making his/her markings to the notes. Every time I work with a producer, I will try to keep a good contact with him/her, so that I know where we are on the songs, and that we are in the same takes all the time, and also that our notation matches throughout the entire recording process.

3.8.6 Risks and Disturbances

The main thing to check before recording anything, is that everyone in the whole venue has their cell phones turned off. Also make sure that people can not walk into the place accidentally while recording. I always lock the doors, so that no outsiders can get inside the church or the concert hall.

Also, I put signs on the doors in some places where the recording is in progress, and that I hope for some silence. Some people tend to touch the doors anyway, so I might even write that do not touch the doors. Big chapel and church doors make a lot of noise, even if only touched or pulled.

Are there any safety considerations, such as having to avoid laying cables in front of fire exits? How long do the cable runs need to be, and who will be letting you into the building to rig? A good recce will save a great deal of time on the recording day, which means you will have more ability to deal with the completely unexpected bombshell which always turns up at the last minute! (Robjohns, H. 1999)

I always tend to place the microphones so that no one can not accidentally bring them down. So that the stand would be heavier, I will put something heavy to keep it put, for example a sand bag. I also put the cables so that nobody will trip on them. I place them to go beside a wall or on the side of the corridor in the church.

I take care that all the singers have clothes that do not make any noise and woollen socks. I also tell them to change the pages of the notation very carefully. (Kari Turunen, a Choir Director, Interviewed 9th of April 2008.)

With the gear, I always take extra adapters, extra amount of wire, etc. It is difficult to leave to get more gear, if you do not have everything with you. Always remember to check your gear list before leaving to the recording venue.

4 Post-Production

The last decision is in the hands of the producer and the choir director, but because it is teamwork, it is good that the engineer approves the material that ends up on to the record. (Jouko Ahera, an Audio Engineer, Interviewed 12th of April 2008.)

Post-production work on a choir recording is only correcting the mistakes you have done at the recording process. This is still a very important phase to get the record sound distinguished, and to the format that everyone involved are happy with it. Post-production work mainly consists of editing and getting the wanted takes on to the recording. Mixing has a minor part, because the solutions for the sound quality are already made in the recording phase.

4.1 Editing

The editing process is very arduous, and pretty boring as well. You are simply going according to notation and trying to find the right place where to cut. It is very mechanical or routine kind of work. It is also a phase, where the project might get delayed, or you might get bored with the project. Editing is just taking the right takes that the producer has selected and putting them together. It is like assembling a puzzle.

One of the first things that editing also includes, is getting all the material to a producer before starting the actual editing, which starts of course according to the requests of the producer. You might want to do it with a program that can export in non-real time, so that it will not take as much time as the actual recording. Personally, I would try to record stereo right away at the recording situation, simultaneously with the actual recording, then I would not have to do the stereo files for the producer anymore at the editing phase.

I made cds for the producer of all the material, so that he is able to listen to it at home and decide what takes are being used for the final version (Murtoniemi, M. 2005, 41).

Everyone does their editing in different ways and techniques. After you have your files on the program you want to use, you of course start to do cut and paste, or clipping and putting the wanted takes to the right order. You do the fades and cross fades, and start finding the right places where to “glue” the parts and pieces together, determine the pauses, etc.

I also found some examples of how engineers do their editing:

1. At the end of each piece, let the applause play for 3 seconds then fade it out over about 8 seconds. Use a fade that starts quickly and ends slowly.
2. If there is background noise such as air-conditioning rumble, insert a fade-in about 2 seconds before the beginning of each piece. Or you may want the track to start right when the music starts; that is with no ambience before it starts.
3. Time-slide the clips to create a 4-second gap between them (or what-ever interval sounds right).

(Bartlett, B. & Bartlett, J. 2007, 136.)

I start listening at the track that I have found the best at the recording session I start of as that being the base. Usually if I am working with amateur choirs it is the first take or the last take, it's hardly ever the middle take. The first thing is to start just fixing the file, fix their performance. I don't think about mixing. If I am using a for instance five ten tracks of recordings I'll edit in those ten tracks. I'll do all the pastes and cuts using all ten tracks, fading between them all. It may not be the best way of doing it. There may be potential dithering noise if you do it with all those tracks but the other option is to mix the whole recording out to stereo and then edit the stereo version. (Mark Corwin, an Audio Engineer and a Professor, Interviewed 19th of March 2007.)

With the pauses between songs, I am creating their “natural” pause between each song. The natural pauses vary from around 0,5 second to 3-4 seconds. This is important especially with live recordings. You create an artistic pause between the songs that you would think that the choir director would keep before continuing to the next song. Therefore, in the mastering process, I will put 0 seconds between the songs, when burning the cd, because I have already determined the pauses between the songs within the tracks.

In choir music, I have learned to make the pauses between songs as long as the natural breathing of the choir takes time in the actual tempo. This makes it possible for the individual song to start in the right tempo. (Murtoniemi, M. 2005, 46.)

In live concert recordings, I leave the applauses where they are meant to be, and I take off applauses that do not belong there, for example within a complete song between parts. But, I

keep the ambience between the songs at all times. This means that there is no fade ins or fade outs to silence. I only take out all unnecessary gaps and long pauses, and cross fade everything to continue smoothly with the “natural breaks”. This means that it is like a one continuous song, but of course each track starts the song from where it begins.

Sometimes the editing becomes very complicated, when the energy, and the way of performances are different in the takes of the same song or part. Combining pieces of the same song or part becomes hard, when the intensity changes rapidly in the cutting point. Here are some good advices from Mark Corwin on what to do when this happens:

If it is dynamics we can fix it but EQ and brightness, the energy and the passion of a line if it changes dramatically from one take to the next, it's very difficult to edit if not even possible. So there may be times when I have to say to the conductor or the performer that I can't use that take if they want me to fix that note. If they want me to fix that note I have to go to another take, and maybe even for longer period previous to that point and afterwards to fether it in properly into the phrasing of the particular line. You can sometimes do that to wait for the phrase to go by and then do the edit as supposed to editing on some beat where there's a loud noise because even with a loud noise or a piano hit you can mask your edit but you may not mask the timbre shifts of the edit if they got energy changing. (Mark Corwin, an Audio Engineer and a Professor, Interviewed 19th of March 2007.)

When you have done your fist edited version of the song, you would normally send it to the producer and the choir director. They will give their opinion, and suggestion to do the next version, if they are not happy with it. The only way is to compromise, and to find the version that everyone can be happy with. You need to be strict sometimes, but spend time to find better takes if necessary, and if there is enough material recorded.

I give them the result and they say “oh could you find a better entrance at measure 52 in the third piece” and I'll look around and I'll usually say no, “that was the best one because all the other ones had a cough or there was an early alto or the tenors were stragling behind it”, little things like that. They'll find problems, but more than likely I also have found that the problem or the section that I got that they call a problem is actually the best that I can get. (Mark Corwin, an Audio Engineer and a Professor, Interviewed 19th of March 2007.)

You have to have a sense of the music and know musical theory in order to do editing well. You also have to have an accurate hearing and ear for the edits to go smoothly and accurately, in terms of music. Test your hearing with different gear, and you will find your own perfect way how to work.

I am used to editing everything through headphones, so that I can get into the details better (Murtoniemi, M. 2005, 44). I always edit through speakers in a studio. I cannot trust the headphones anymore at this point. The speakers are much more truthful, when it comes to hearing the pitch and the frequency range. Also, headphones are more specific and more accurate than the speakers, and you might lose the overall picture, if you are only monitoring through headphones. Also, you get a better sense of the reverb too, when listening through speakers.

4.2 Mixing

Everyone has their own opinions about mixing. Some engineers prefer not to do much and rely on the natural sound that they have captured in the recording situation. Some engineers might do even more than is necessary.

Mixing is based on matter of opinions. There is no right way to do it, but mainly in general the goal is to get a natural and good tone, where the stems of the choir are in balance, and in appropriate ratio to the acoustics. (Jouko Ahera, an Audio Engineer, Interviewed 12th of April 2008.)

I do not have any rules for mixing. I may use some equalizer and compression if needed. (Amandine Pras, a Producer and an Audio Engineer, Interviewed 16th of April 2008.)

When I start my mixing, I listen to the sound first as it is, and start to find the ways what to do to it, if it is not good enough, or if something is missing. But, mainly I tend to do my mixing already, when doing the actual recording. This happens by changing the places of the singers, positioning the microphones and so on. You cannot change the alts further back in the mix after the recording is done, if they stand out too much in the recording.

To me a good mix is a if I can hear all the words, I can hear the notes well, I hear good S.A.T.B., good spread in the musicians, if I can hear the space being complementary to the choir and not over shadowing it, you know having too distant of a recording you

start to hear too much of the space, and the space now becomes muddled like sitting up in the balcony. I prefer to have clarity first. (Mark Corwin, an Audio Engineer and a Professor, Interviewed 19th of March 2007.)

Mixing is really tiring for your ears, and especially when working with small differences, when mixing classical music. I have heard that after around 4 hours you cannot hear the differences and changes truthfully, because your ear is too tired. That is why mixing should be done with “fresh” ears. You should give your mix at least another listening after a couple of days of your mixing session. Then you can hear how it really sounds like. Also, remember that in time you also get used to the sound, so do not stretch your mixing to a too long period of time either.

I admit that I have used in some of the songs for example plug-ins like Waves Maxxbass. It is probably not the best solution, but if the client wants it to sound more like a dark gospel choir, and the technology gives a chance to do it, then why not use it. (Murtoniemi, M. 2005, 46.)

I think that you should be very careful with extra plug-ins that really affect the sound quality. These things should have been thought of at the recording session, rather than afterwards try to change the sound into something completely different. All your processing will do its best to remain discreet, indistinct. Unless you are going for a purposefully distinct sound, use caution.

There might be an assumption that when the engineer is able to see the music as sound waves, he is also able to wipe out with the mouse the singer who is singing wrong. Also it might be assumed that you are able to change the balance of the choir afterwards. (Koivusalo, M. SULASOL 1/00 III.)

Actually there are plug-ins that I have used, such as Cedar Retouch (www.cedar-audio.com), and reNOVAtor (www.algorithmix.com), with which you can see the music as colours and shapes, kind of like a Paintshop Pro for sound. You are able to mould the shapes of the music and take off sounds, for example if someone is coughing or making noise, you are able to take it off, and it sounds like it has never even been there. You are also able to change the pitches of different sounds, shape the harmonies, and replace, copy, or take off sounds. These plug-ins are very time consuming to work with, and you have to be careful not to mess up with the tones and harmonies drastically, because it might start to sound unnatural. Also, there are sounds and situations, to which you are not able to do anything with these plug-ins. In

Finland, there are only a couple of studios that have these kinds of plug-ins, because of their high price. But they are becoming high quality plug-ins in mixing acoustic music.

4.3.1 Equalization

There are a lot of strong opinions about the equalization, whether to use it or not, and if using it, then to what extent and how much. I have figured out that I will only use it, if there is something wrong with my frequencies, and the recording does not sound like it is supposed to. I only use it to make my recording sound more natural, not to make it sound something else than what the recording already sounds like. I mainly bring up frequencies that are hidden or missing, or take down the ones that are standing out too much. These adjustments are very discrete, and normally not that noticeable for most people.

Fortunately, a recording having a skewed tonal balance can often be salvaged with equalization. An effective tool for this purpose is Harmonic Balancer (www.har-bal.com), which shows the spectrum of the recording and lets you equalize it as needed. (Bartlett, B. & Bartlett, J. 2007, 137.)

I use EQ some on choir recordings, to help me make up for the mistakes made in mic placement. But your goal is a natural sound, right? Lots of EQ will start to make the recording sound artificial, a no-no in this world. The rule is easy does it! EQ can be a life saver, but it needs to be used sparingly on choir recording. (Weaver, A. 2007.)

Some engineers refuse to use the equalization, especially on the main stereo pair. I really think that these are matters of taste, but I would only use it to correct mistakes in the frequency field of the recording. I would not take anything away completely, for example I would not use a low-pass or a high-pass filters.

Eq on the piano if I am using a highlight microphone. I will eq that, I'll take out some of the mids and the low frequencies because I don't need the body of the instrument, I need more of the clarity of the instrument. Most frequently the piano is either in half stick or all the way down or maybe on a small block so the clarity of the piano is the problem, getting it nice and bright. The high light microphone on the piano I may eq, but the stereo pair, never, or especially omnis no need for eq. (Mark Corwin, an Audio Engineer and a Professor, Interviewed 19th of March 2007.)

4.3.2 Reverb

Because the preferred reverb is normally between 2-3 seconds, the acoustics cannot always provide the perfect outcome, when it comes to the reverb. Sometimes the recording place is way too dry, and even in spaces with good acoustics, it might still be lacking on the length or richness of the reverb.

I tend to record closer to the ensemble generally because I like to hear clarity. I find many of the people; many of the artists don't like it that dry. I can hear what the reverb is, they want to hear it almost washing out things. So I will add that artificially with good reverberation plug-ins or out board reverb gear, if I need to. (Mark Corwin, an Audio Engineer and a Professor, Interviewed 19th of March 2007.)

You need to remember that people hear reverb differently, and that as an audio engineer you are able to hear the reverb better than people who are not working with audio. To you, the reverb may seem a lot, but to the client it may seem too dry in most cases, because they cannot hear it as accurately as you do. Sometimes you need to put more reverb than you would like to, because it might not be too much for the client.

You can record in good sounding spaces, but sometimes you need to fill things out just a tad. A reverb (set to a gentle sound, remember!) will do wonderfully. The problem is that many times it is very difficult to get a pleasing sound. With so many knobs to turn, a reverb plugin can be frustrating when you don't know which one to turn to get the sound you're looking for. But take heart, you will find it eventually, though it may take you a while at first. (Weaver, A. 2007.)

I would use church and chapel reverbs with a warm touch, and not too big size, with around 2 second length of the reverb. These are just some things that I have liked, when mixing choir music, especially with religious music. With pop and jazz choirs, I prefer different kinds of hall or room reverbs. There are some good reverb plug-ins in the Waves Gold Bundles plug-ins (<http://www.waves.com/content.aspx?id=166>), like True verb and Renaissance. There are a lot of good outboard gear too, like Lexicon (www.lexiconpro.com) or TC System 6000 (www.tcelectronic.com/System6000.asp).

4.3.3 Compression, Levels and Dither

With the compression, you normally make the pop and rock songs as loud as possible. Well, with classical music this is completely different. Most of the engineers tend to leave the dynamics for the choir to do, and not to touch it afterwards. I might use it, but very very lightly, so that it does not grab too much of the sound. As in many of the other matters, when it comes to mixing choir music, in using the compression too, there are also many opinions about it. Everyone has their own way of doing this, but normally there are no classical recordings that have been compressed heavily.

I don't use any compression, so I really believe that the loudest section can go to -0.01 db and everything else from there is quiet. [...] At least my dynamic level is the full dynamic level. Compression for classical music is a process for radio play, it's not for the pure recording. It should be as untouched as possible. (Mark Corwin, an Audio Engineer and a Professor, Interviewed 19th of March 2007.)

Compression is another handy tool, but again, to be used with caution. (As a matter of fact, anything you use on a stereo recording or choir recording should be used with caution!) A compressor will start to suck away the dynamic range of a choir, taking away their work on subtle dynamic nuance. I generally use a touch of compression, but keeping a good deal of breathing space for the group. (Weaver, A. 2007.)

Some automation can be done to the volume levels, for example if the beginnings of the songs tend to start way too quietly, you can raise it a little, or if you think that some parts have drastically too much of volume differences. But otherwise, the choir should take care of their balances and changes with the dynamics. The adjustments should not be dramatic, and not interfere the natural dynamic changes of the choirs interpretation.

Sayings like 'If you are forced to raise the volume more than 3 decibels, you have done something wrong'- should go to the garbage (Murtoniemi, M. 2005, 46).

I personally would be careful with raising the dynamics too much. I only bring the highest peak somewhere close to -0.1 dB. But I rarely normalize it. I bring the level up in some other ways rather than with normalization. Also, normalizing afterwards, if the level is too low, will always bring all the hiss and noise sounds up as well, which you did not hear during the recording situation. I do it only, if the levels are so low that I cannot bring it up in other ways.

Once the program is equalised (if necessary), import the equalized file and normalize it, so that the highest peak reaches -0.1dBFS. Finally enable dither and export the normalized mix to a 16-bit stereo file. (Bartlett, B. & Bartlett, J. 2007, 137.)

Enabling dither (low-level noise added to the signal in order to reduce the effect of quantization error) is basically done in the very end, during mastering. Mainly, mastering engineers tend to have the ears for different dithers, and claim to hear the differences between them very well. Also, the engineers with the Tonmeister education are supposed to hear them as well. The dither actually means the following:

With signals of large amplitude, there is a little correlation between the signal and the extraneous signal due to quantization error; the latter is heard as random noise at a very low level. With low-level signals, however, noise due to quantization error has some correlation to the signal, and thus analog noise signal (or *dither*) is sometimes added to the audio signal prior to sampling to randomize the effects of quantization error. (Rossing, T.D. 1990, 558)

4.3 Mastering

Especially in America, the engineers tend to send the mixed versions to the mastering engineers for the “final touch”. No matter what kind of music it is; pop, rock, jazz, classical. Here in Finland, it tends to be a little different thing, when it comes to classical music. The engineers normally do the mastering themselves.

Why use for example a mastering service after you have recorded, mixed and edited everything. I believe that you have the a better idea on how the outcome should sound like, than a professional mastering engineer, who would need to do decisions in a couple of hours, without knowing anything about the actual recording process. The situation is very different for example in hit music, where there are different people doing the recording, and mixing, and in different studios with different people etc.. (Jouko Ahera, an Audio Engineer, Interviewed 12th of April 2008.)

If you are not doing a live concert, where the order of the songs is the same as in the concert, then the order of the songs is decided by the choir director or the producer. This can be also done during the editing phase, but I sometimes leave it to the very end.

The choir director or the producer makes the decisions about the order of the songs on the record. At this point, I got some good advice about the structure of the record. After the agile songs in the beginning comes a calm song, which is followed by a new vivid period. Then there is another calm song and also followed by a new vivid period. After this happens again the last song is the great and happy finale. (Rantanen, E. 2001, 34.)

Especially in vocal music, the songs need to be in an order where the song matches together by key with the previous and following song. With all the keys in succession, with the keys as close to each other as possible, based on the quint circle, and the songs to a progressively rising order towards the ending of the record. Also, the dropping of key before starting a song by the same key does of course not provide a good image, so also this is to be taken into consideration, when thinking about the order of the songs, or at least the flips in the tone are to be corrected also between the beginnings and endings of different songs. (Murtoniemi, M. 2005, 57.)

It is also important that the levels in the overall volume are pretty much same in all of the songs. You do not want to have one song coming out much louder than another one. The overall image needs to be good and whole. Also, remember to name your track perfectly, and include the tracks with the cd text on to the cd, when you are burning it with your final material.

Remember to give the cd a through listening with many different players and speakers, for example, in your car, from very bad speakers to very good speakers, in different studios, at home, etc. If the cd sounds good and acceptable everywhere that you listen to it, then you do not have to change your mix or anything to it anymore, and it is finished.

To me the issue of utmost importance, and what I consider mastering to be, is that I listen through the entire material once more, and check that there are no mistakes, and that everything sounds the way it should sound like. I never give a cd to a client that I have not listened through completely.

5 What Are the Best Choir Records?

In the following chapters, I will present the nominated or the award winning records of this year. In Finland, there are less awards and acknowledgement of choir records than in USA or Canada.

5.1 Choir Activity in Finland

There are around 1400 choirs in Finland. Finland has a lot of choirs, but only few of them are on a professional level. The biggest choir associations are The Finish amateur Musicians' Association with 360 choirs, and the Finnish Association for Church Music with 460 choirs. STM- music (Suomen Työväen Musiikkiliitto) has 150 choirs, and the Swedish Choir and Music Association of Finland has 240 choirs. (Lantto, J. 2007, 7)

I noticed that there are a couple more associations for both female and male choirs. The Finnish Opera Choir is the only professional choir in Finland (The Finnish Opera, 2008).

5.2 The Recognition of Choir Recordings

Overall, the recognition of choir recordings is very limited. The choir records will probably never achieve such huge recognition as pop and rock records, or even as classical orchestra records. There are few ways to get recognition, and also there are a lot of choir competitions where choirs attend from everywhere in the world.

5.2.1 Finland

Every year, Finland's Choir Directors Society elects the best choir recording. The judges vary every year, but they are assembled from professionals from the executive committee, and also from the executive committee of Sulasol The Finnish Amateur Musicians' Association.

To be elected, the choir recording needs to meet at least the main criteria that are a very high artistic level and very ambitious material is being performed. Every year, the election depends on the personal opinions of the judges, but mainly the requirements that the choir also needs to meet are that the performance of the choir is coherent, and the timbre of the choir is clear and correct. Mainly the level of the arriving recordings is so good that technical issues have not been bothering the judges. *“If there is a good choir performance recording with bad sound quality, it would most likely not get elected.”* (Johanna Laukkanen, Executive Director of Finland’s Choir Directors Society, Interviewed 1st of March 2008)

Every year, there is also an election for the best choir director. Nominations are made by the members of the society, and the members vote for the best choir director.

5.2.2 United States and Canada

In the United States, music Grammys are elected within classical music: best classical album, best engineered album, best opera recording, the producer of the year, best orchestral performance, best choral performance, best instrumental soloist(s) performance (with orchestra), best instrumental soloist performance (without orchestra), best chamber music performance, best small ensemble performance, best classical vocal performance, best classical contemporary composition, and best classical crossover album.

GRAMMYS 2008:

Best Engineered Album, Classical:

Grechaninov: Passion Week. John Newton, engineer (Charles Bruffy, Phoenix Bach Choir & Kansas City Chorale)

(GRAMMY Awards, 2008.)

Best Opera Recording:

Humperdinck: Hansel & Gretel. Sir Charles Mackerras, conductor; Rebecca Evans, Jane Henschel & Jennifer Larmore; Brian Couzens, producer (Sarah Coppen, Diana Montague & Sarah Tynan; New London Children's Choir; Philharmonia Orchestra)

(GRAMMY Awards, 2008.)

In Canada, they select the Junos in classical music: classical album of the year; solo or chamber ensemble, classical album of the year; large ensemble or soloist(s) with large ensemble accompaniment, classical album of the year; vocal or choral performance, and classical composition of the year.

JUNO AWARDS 2008:

There were no winning choir records this year.

Classical album of the year: vocal or choral performance nomination:

Buxtehude – Membra Jesu Nostri *Les Voix Baroques*

(JUNO Awards, 2008)

5.3 The Future of Choir Recordings

What is the future of choir recording? What improvements will there be? The technology has changed, and in a way made it easier to make recording with better quality, but otherwise I noticed that not everything changes. There has always been vocal music, and always will be.

There are not enough publishers in Finland for choir music, so that is why the recording possibilities are so narrow. I would hope more appreciation for choir music overall. (Titta Lampela, a Producer, Interviewed 13th of April 2008.)

The Internet will probably improve the spread and availability of choir music in the future. There are possibilities with the distribution of the Internet, which no one has really figured out yet, and started to take advantage of it either.

The actual CDs and records are starting to disappear. I hope that the choirs are able to get into the distribution of the Internet music sale more. If you are able to build the right ways, the Internet would be a great way to bring out more margin music available to the people. This would be also a cheaper way, when there are no costs in printing and copying CDs, because nowadays it is really hard to get back the money you have put into it, because the markets are so small here in Finland. Also, it would make things so much faster, and you would not necessarily need to do an hour long recording, but instead maybe a package of 15 minutes worth of material. There are a lot of interesting and also global opportunities with the Internet. (Kari Turunen, a Choir Director, Interviewed 9th of April 2008.)

The Internet is helping also choir music, when it comes to distribution. And I hope that for example wma 9 encoder that can pack up audio in surround, would become acknowledged. Choir music would be perfect and natural to listen to in surround, because you can adjust the acoustics with the volume of the back speakers. (Ari Koivumäki, an Audio Engineer, Interviewed 4th of March 2008.)

The level of choirs have become a lot better during the time I have worked in this business, and that is since 1970. I do not see any reasons that would stop the evolution from going forward. Nothing can stop the technology, and there will always be new methods and formats, for example DSD and DXD. You just need to be able to choose the ones that are really useful, also for the consumers. (Jouko Ahera, an Audio Engineer, Interviewed 12th of April 2008.)

Hopefully, soon you are able to transfer your big recording files easily from one place to another. How about, if you were able to control your recording units of your studio from the recording place and the recordings would go straight to your studio computer? I personally hope that the microphones would also become completely wireless in the future. And it would also be great, if the preamps were as plug-ins in the laptop. It would also be great, if the stands were made from a very light material, but were still steady, because waiting for floating microphones might take a while.

6 My Own Recordings

I have been recording most of my choir recordings during my exchange year in Canada, Montréal. I did mainly concert recordings, because it was the American way to record choirs and orchestras. Some of them were even published. Most of the choirs were recorded in a live concert. The followings songs are attached to this thesis on an audio-CD as an appendix.

6.1 Song no 1: Tampereen Yliopiston Laulajat

Túrót eszik a cigány / Zoltán Kodály

Aitolahti old church, Tampere, Finland – Album recording, January 21st to 22nd 2006

I made a recording to the Choir of the University of Tampere (Tampereen Yliopiston Laulajat). I was ambitious, and wanted to record it surround, and so I did. The choir ended up publishing only the stereo version because of financial and technical issues.

The church was Aitolahti old church, and it was a really small church. I was forced to add reverb afterwards. The choir was situated in a half circle, like an arc, in front of the microphones, you can see this from Figure 18.



Figure 18. The choir in front of the microphones.

I had the Akg 414 microphones in a metal bar of Burmajsters array. With this surround setup, I had B&K omni microphones at the back of the church before the balcony, and rather high up. This microphone postioning can be seen in Figure 19.



Figure 19. The microphones from the choir's perspective.

6.2 Song no 2: Chantons Sing Noël

Children Go Where I Send Thee / P. Wedd

Performed by :
 Concerto Della Donna
 Choeur Saint Laurent
 Chœur des Enfants de Montréal

Oscar Peterson Concert Hall, Montréal, Canada - Concert Recording, December 2nd 2006

In Concordia University I recorded a live concert called Chantons Sing Noël, before Christmas time. The main pair was Brauner phantom cardioid microphones in a DIN stereo technique system. There were also three Neumann 183 omni microphones hanged above the choir as L-C-R. There were also two supporting microphones, Neumann U87s on the far sides

of the stage as ambient L and R. They were placed on the very side of the stage, which continued from both edges towards the audience. This was because there were three different choirs on stage (over 100 people). Two of the choirs were standing on the edges of the stage, and one choir in the middle of the stage. They were all singing at the same time, and also with the audience.

In this particular song, all the choirs are positioned in the middle of the stage as one big choir. The microphone placement for this song can be seen in Figure 20.



Figure 20. All three choirs in front of the microphones.

6.3 Song no 3: Concordia University Chorus

Mass in C Major "Coronation" KV 317 Gloria / W.A. Mozart

Oscar Peterson Concert Hall, Montréal, Canada - Concert Recording, December 5th 2006

I recorded a live concert at the Oscar Peterson Concert Hall with the Concordia University Chorus. I had the Brauner Phantom cardioid microphones in a DIN system as the main pair, and also Neumann 183 omni microphones hanging from the ceiling as L-C-R. Unfortunately, I was not able to put ambience microphones, because it was a live concert. There was also a spot microphone for the piano. The microphone placement can be seen in Figure 21, page 89.



Figure 21. The university choir from the side with the microphones.

6.4 Song no 4: An Evening of Spirituals

Every Time I Feel the Spirit / arr. Wm. Henry Smith

Performed by

Imani Gospel Singers. Directed by Marcia Bailley

Oscar Peterson Concert Hall, Montréal, Canada - Concert Recording, December 8th 2006

In this gospel concert, I had the Brauner cardioid microphones set up as NOS system, and I also had two Neuman U87 supporting microphones as left and right beside the main pair. Also, I had the Neumann 183s set up in the ceiling as L-C-R. It was hard to mix this afterwrds, because all the artists and choirs in this concert were moving a lot while singing, and also different line-ups were located in different places of the stage at different times. The main stereo pair can be seen in Figure 22, page 90.

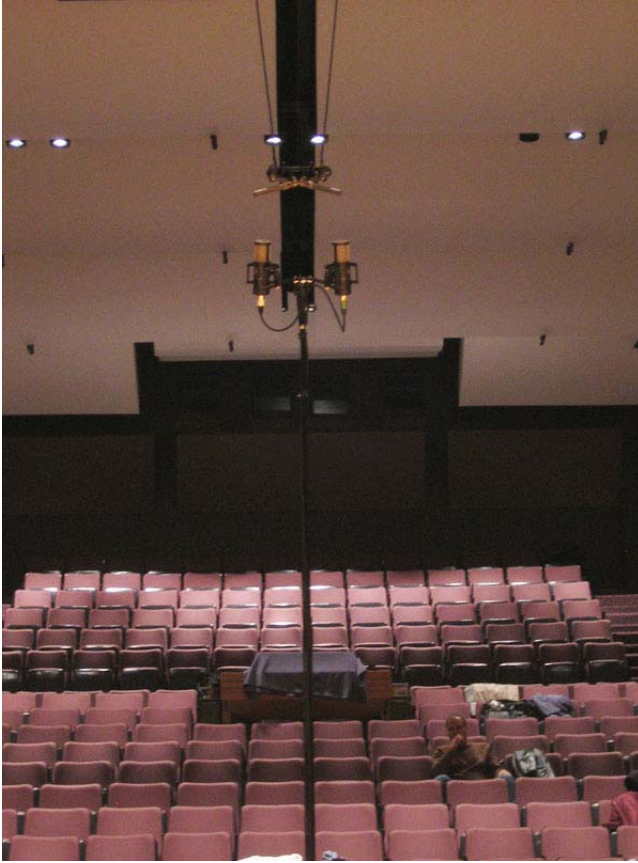


Figure 22. The main stereo pair.

6.5 Song no 5: Studio Musique Ancienne de Montréal

Le Messie S'en Vient ! / Le Chef - D'œuvre De Handel

*St. Jean Baptiste Church, Montréal, Canada - Concert Recording,
Recorded Live December 3rd 2006*

This concert was very enjoyable to record, because the musicians were very professional, and they are considered as top performers in the world. The church was really big and beautiful with a long, around 4 second reverb. I had a Brauners pair set up as ORTF, because the performers were positioned to a very wide area.

I also had two Neumann 183 omni microphones at the back, and in front of the choir as left and right. I also had four solo microphones for the soloists and in front of the stage, two on both sides of the main pair.

6.6 Evaluation

I have been very fortunate to have had the opportunities to record different choirs. Now that I look back at the recordings that I have done, of course there are things and techniques that I would like to do differently. But I am pleased with the way the recordings turned out. I did not use that much of mixing on to them, because I wanted them to sound very natural. You can hear that I like clarity and close miking a lot.

After I had found a good technique to record the choir, I think I stuck to it too much. I should have been trying out different things and techniques, rather than relying on the good sound that I got with the few techniques.

Also, recording as surround in a more interesting way is driving me as well. In the University Choir of Tampere, I had an opportunity to record them as surround, and after the actual album recording was done, I had the choir around the surround microphones in an oval shape. They sang a couple of Finnish songs, and after arriving to Canada, where I was studying Electroacoustics, I mixed the choir to swirl around, and the men and women were changing places in my quadraphonic electroacoustic piece. It was presented in an Electroacoustic concert series at Concordia University.

With live recordings, you do not have to worry about producing or editing. I would have wanted to produce more, develop myself as a producer more, and give it that final touch in that way too. Also microphone technique testing was impossible in some concerts. The microphones are still considered to be a disturbance to the audience and blocking the view to some extent. There were also choir directors that did not allow any stands on the stage.

Hopefully, in the future I am able to continue my exploring in the world of choir recording, and hopefully live recording situations land to Finland as well, because honestly the live recordings are much more interesting to listen back, than most of the album recordings that have been polished too much.

7 Conclusions

In this thesis, my purpose was to find out what a recording engineer needs to know before starting to record a choir recording, in order to make it well. I think I found some answers and different ways and methods, the only problem is that everyone has their own ways of doing a choir recording. There are a lot of different ways and different techniques to do it, and also the situation is always a little different every time. Because of this, a good choir recording is still very hard to determine.

There are also different music styles in the choirs, and the music is the main thing in everything. It is what determines how everything should sound like. It is also what determines the way the producer thinks about the songs, and how the choir director conducts the choir. What I have noticed, is that it also makes people behave differently; if it is classical music the manners are more conservative than, for example with a jazz choir.

But even so, all the people who I have worked with, and talked to, or interviewed, have the same base. They are driven by the same ways and manners that most of the people in the same profession are doing, and have been doing for years. It is simply something that has been acknowledged to be a good way of doing things. These manners and ways cannot be learned from the books, you just need to start doing it and learn from your mistakes. The work teaches you, as well as the people around you in this industry. Soon you will find the way that works for you best, and you will also make your own inventions about how to do things easier, faster or better.

Making the recording is absolutely team work. As an engineer you can not succeed in recording a great recording without any help of the other people involved. You need to have social skills, and to be able to communicate clearly, even though people have different words for the same meanings. So, the ability of handling people is very crucial.

Also you need to have courage - courage to speak your mind and tell what is possible, and what is not possible, when it comes to technology, to the others involved in the recording process. While you need to behave and do your job like a professional, have the courage to try out different things and let yourself be creative. You too are creating art, in addition to the artist's performance, it is not just pushing the record button.

The main factor is still the acoustics, of course, when it comes to the quality. Without the acoustics, the recording is basically nothing, no matter how professional the people involved are, if the acoustics is fighting against the recording. As an engineer, you should take responsibility of choosing the recording venue. It is very much connected to the musical style that is performed. The acoustics define your sound.

Naturality is one of main words as well, after reading this thesis through. Stereo techniques were meant to capture the playing as it is, and they still are. It should be overpowering the recording. It is the main character in recording acoustic music. One of the engineers job simply is to capture, and get the performance on the cd the way it sounds to the audience.

Even though there are differences in making the record technically, I have always been taught that it is just technology. Technology always changes, it is not of importance, but the music is; the performance and capturing it just deals with technology. You just need to find the ways to get it to sound like the music is supposed to sound like. It is not about the mathematics, or physics, or placing the microphones exactly with the accuracy of a millimetre in its place. I never look at the meters all the time, I listen and use my ears. After all, what you hear is what counts.

And it all comes down to the consumer, the listener who buys the records. The listener does not know how it was made, and usually is not even interested about that either. The important thing is that it sounds good to the listener, and that there is nothing that would irritate the listener's ear in any way. The best way is that the listener feels like he/she is hearing it like in a live concert.

This is why I came to the conclusion that the listener defines the quality of the recording. It is the consumer who gives the criticism, defines the limits, and demands more or less. I also think that the surround sound is dependent on the consumers as well. It is ready to be done, we already know something about how to get it out there, and as soon as the consumers are ready for it, then we will give it to them.

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Appendices

A. People Interviewed

Ahera, Jouko

An audio engineer from Porvoo. Owns a company called Äänityspalvelu Jouko Ahera. He has been making recordings since 1972 and has recorded very famous records in Finland. He is specialised in recording acoustic music and has also recorded music for film. Awarded with the record of the year awards by musical journalists from the TV and radio, and also received awards for amateur music and international recognition by YLE.

(<http://www.aanityspalvelu.com/>)

Interviewed: 12th of April 2008

Corwin, Mark



Dr. Corwin is an Associate Professor of Music in the Electroacoustic Studies programme at Concordia University in Montréal, Québec. He teaches courses ranging from introductory electroacoustics and recording studies to electroacoustic composition and advanced recording techniques.

He currently holds memberships in the Canadian Electroacoustic Community (CEC), SOCAN, and is an honorary member of the Pi Kappa Lambda National Music Honors Society in the United States.

(http://music.concordia.ca/music_faculty/mark/corwin.html)

Interviewed: 19th of March 2007

Koivumäki, Ari



Ari Koivumäki is a senior teacher at Tampere Polytechnic School of Art and Media and an audio engineer. He is also a Master of Social Science and a Licentiate in Theatre and Drama. Koivumäki has been a member of the AES since 1981 and has experience of recording acoustic recordings for YLE. He has worked with choirs like Campanella and Helsingin Yliopiston Laulajat. Koivumäki has also worked with Pekka Nikula on several choir recordings. Koivumäki is also one of the creators of the “Äänipää”, a web site focusing on sound narrative: (<http://www.aanipaa.tamk.fi/english.htm>)

Ari Koivumäki is a member of the the Acoustic Ekology Club of Finland.

Interviewed: 4th of March 2008

Lampela, Titta



Working primarily as a Music Teacher in a comprehensive school and has been a producer in many choir projects.

She is also a soprano singer in Lumen Valo choir and the choir Director of Hiljaa Ensemble choir.

(<http://www.sunpoint.net/~hiljaaensemble/>)

Interviewed: 13th of April 2008

Nikula, Pekka

Pekka Nikula is the principal of the music classes in Pispa school, Tampere. He started his career in choral life by singing 11 years in the student choir of Tampere University. During many instrumental studies he quickly noticed that the choir is his real instrument. He has conducted several choirs, ensembles and the Big Band of the music classes in Tampere. Nikula has also arranged a part of the choir's repertoire. He is devoted in children and youth choirs by working as a vice president in the Association of Finnish Youth Choirs and as a member of board of SULASOL (Association of Finnish Singers and Musicians).

(<http://www.tampereenmusiikkiluokkientuki.net/sympaatti/sympa/contacts.htm>)

Interviewed: 15th of April 2008

Pras, Amandine

A young and a talented producer and also an audio engineer from France.

Currently doing her Ph.D. in Master of Music in Sound Recording program at McGill University. (One of the 'Tonmeister' Schools.)

Interviewed: 16th of April 2008

Turunen, Kari

Has a Degree Programme in Orchestral and Choral Conducting in Sibelius Academy.

Choir director of Akademiska Damkören Lyran choir since 1998 and chamber choir Näsin Ääni since 2002. Has also been singing in Lumen valo choir since 1993.

He is also a lecturer and responsible of choir activity at Pirkanmaa University of Applied Sciences. Also a member of Finland's choir Directors Society since 1977 and director of SULASOL between years 1990-1996.

Interviewed: 9th of April 2008

Laukkanen, Johanna

Studied to become a choir director at Pirkanmaa University of Applied Sciences.

Choir Director of Vanajan laulu choir and sings in Näsin Ääni choir.

An Executive Director of Finland's Choir Director Society

(http://www.vanajanlaulu.fi/index_tiedostot/kuoronjohtaja.htm)

Interviewed: 1st of March 2008

Special thanks to:**Austin, Kevin**

Kevin Austin is an Associate Professor of Music in the Electroacoustic Studies programme at Concordia University in Montréal, Québec. He is also an electroacoustic composer.

Baltzar, Birgit

Translator. Thank you for proofreading my thesis.

Leonard, Theresa

A director of Audio for Music & Sound at The Banff Centre.

(http://www.banffcentre.ca/faculty/faculty_member.aspx?facId=272)

Ylipahkala, Piritta

A singer in the Tampere University Choir, Tampereen Yliopiston Laulajat.

B. Company Websites

AEA www.wesdooley.com/

AKG www.akg.com

Apogee www.apogeedigital.com

Avalon www.avalondesign.com

Brauner www.brauner-microphones.com

DPA www.dpamicrophones.com

Focusrite www.focusrite.com

Lavry www.lavryengineer.in.com

Meitner designer www.emmlabs.com

Millenia www.mil-media.com

Neumann www.neumann.com

Pyramix www.merging.com

Pro Tools www.digidesign.com

Quik Lok www.quicklok.com

Sadie www.sadie.com

Schoeps www.schoeps.com

Shure www.shure.com