REPORTS ON SURROUND SOUND FOR RADIO DRAMAS

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1. Introduction

Surround sound at NHK has a 20-year history. Radio drama mixers have always served as engines for producing surround sound programs. It is worthy of notice that they have promoted surround sound at NHK. Radio drama mixers have been always thought about how they can help realize the producer's design for the program precisely as well as effectively. It was natural that they became interested in surround sound because of the limitations of stereo sound, and sought enhanced realism and emotional experience.

In the early 1980's, when surround sound became the standard in motion pictures, there were no surround-sound radio or television programs. Therefore, NHK's radio drama mixers began to learn how to create surround sound from motion pictures. They established surround sound for broadcasting through trial and error. Now NHK broadcasts not only radio dramas but also TV dramas, music, sports events and feature documentaries in surround sound. We have a wealth of experience in and data on producing surround sound -- enough to convey our know-how around the world.

We think exchanging information on surround sound with global experts can help produce high-quality programs. NHK is willing to provide foreign broadcasters with physical supports for surround sound productions. Nothing would give us greater pleasure than to have readers of this paper become interested in surround-sound radio dramas.

This paper covers five points:

- Advantages of surround-sound radio dramas
- Strategies for success
- Surround sound for radio dramas

- The global trend of digital radio
- Conclusion

2. Advantages of surround-sound radio dramas

What are the advantages of radio dramas? I think they are as follows:

- A radio drama stimulates the listeners' infinite imagination because it has no pictures. It is cinema sound without pictures.

- Surround sound helps precisely realize the producer's concept for the program. Surround sound enhances more reality /emotions /energy /space.

- We have rich experiences with mono and stereo mixing. We can apply these experiences to surround sound.

- We can deliver 5.1-channel surround sound over the standard two-channel radio broadcasting system.

- Anyone with an AMP for DVD can enjoy surround-sound radio dramas at home.

  They don't have to purchase new equipments for surround-sound radio dramas.

- The production cost of a surround-sound radio drama is about the same as that for a stereo radio drama.

Surround-sound radio dramas can form the foundation for producing programs regardless of program category because the technique for creating a storyline with only sound can be applied to all programs.

3. Strategies for success

What strategies should be pursued for success? I believe they are as follows:

- Convince your boss to produce programs in surround sound.

  Most bosses are reluctant to try new things. But if you don't convince your boss, you will never get the chance to produce surround-sound programs.

- Find opportunities to mix surround sound.

  If you don't make positive efforts, you will not get the chance to mix surround sound. You should find such chances on your own.

- Set up good mixing condition.

- Consult experts on surround sound, ask for their suggestions.

- Share know-how with global experts through exchanging information.

NHK believes we are taking a lead in delivering the best surround-sound experiences to our listeners. Please consult NHK on surround sound if you try to produce a

surround-sound program. We promise to do our best so that you can create good surround sound.

4. Surround sound for radio dramas

NHK has accumulated enough experiences in and data on producing surround sound. I will covey our know-how to you.

4.1 Production procedure

The production procedures are as follows:

- Pre-production
- Dialogue recording
- Dialogue editing
- Foley recording
- Field location recording
- Scoring music recording
- Pre-mix
- Final-mix

In NHK, the Japan Broadcasting Corporation, only one mixer takes care of the whole production, recording dialogue, foley, music and final mix. This is NHK's unique method for producing radio dramas.

I will explain surround-sound radio dramas in line with this procedure.

4.2 Pre-production

There are a lot of things to think about when producing radio drama programs. The top priority is sound design. And then we chose the microphones and the effecters for dialogue or music. Six fundamentals of surround sound designs for dramas will help you quite a bit.

4.2.1   Six fundamentals of surround sound designs for dramas

Six fundamentals of surround sound designs for dramas were proposed by Mick SAWAGUCHI at 1996 ASE Copenhagen as following:
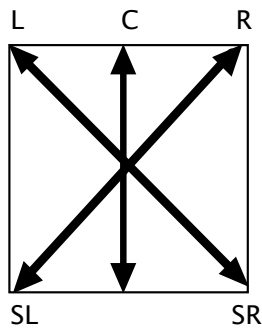
- **Surround ambience**
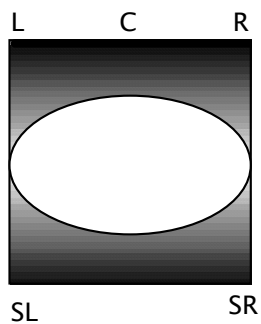
This is the most basic design for surround sound in any program. It can convey a sense of space.

It indicates more clearly to the audience what is going on in a particular scene, or implies a hidden layer of the story. The key difference between music ambience and the drama is that on-the-spot location recording of ambience does not always serve effectively in storytelling. It requires sound designers to create a composition of several more suitable
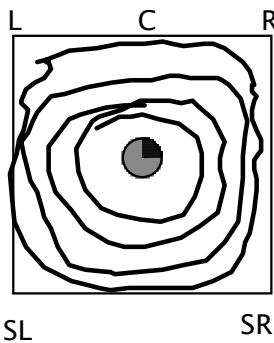
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sound elements.

- **Fly-over**

L   C   R

SL   SR

Specific objects pan from front to back or vice versa. This is an ideal example of sound presentation that has a sure and automatic impact to listeners even if they are not familiar with surround sound.

- **Horizontal rotating**

L   C   R

SL   SR

This technique makes the audience feel as if they are in a whirlpool or a spiraling air flow, or standing in the center of a merry-go-round. It is not used very often except when special effects are required. One reason is that this technique may strongly affect the audience.

- **Preceding / After image effect**

L   C   R

SL   SR
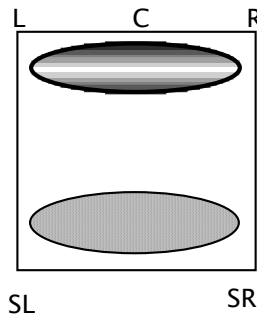
The preceding/after sound field is a sound design that implies an event or activity that may follow the ongoing situation. To achieve this effect, the sound must be short, with an impact; just by hearing it, the audience should have some idea about what is going to happen next.

- **Sound shower from top**

L   C   R

SL   SR
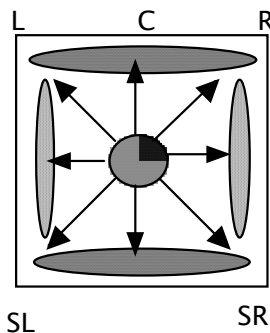
The surround effect gives a sense of height, as if the sound is showering the listener from above. Theoretically speaking, it is impossible to present height information by means of a 5.1 horizontal plane. But it takes advantage of practical surround speaker placement on a wall or ceiling – i.e., normally higher than where the listener is seated. We can make the audience sense the height psychologically.

- **Loud sound feels closer**
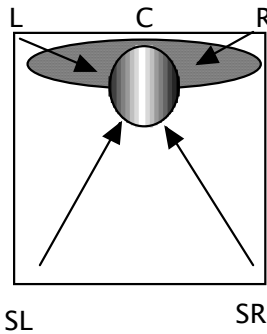
This technique is used when the designer wants to highlight particular sound effects. The main portion of the signal content is placed at the center channel, with processed portions distributed to the L, R, SL and SR channels for enhancement. In this way, the designer can enhance a wide range of sound effects, and increase the sound level much more than would be possible from a single channel. Furthermore, with these multi-channels, the sound designer can make the sounds seem much closer to the listener.

4.2.2 Three fundamentals of surround sound design for music

For scoring music, usually the front L-C-R speakers are used for the main music and the rear configuration is for ambient components. The center channel is primarily used for source music in dramas and all the channels effectively undertake ME.
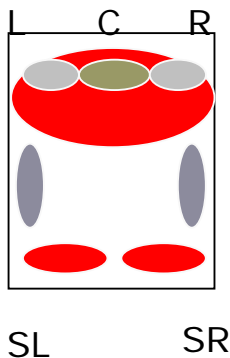
Three fundamentals of surround sound design for music are as follows.

- **Stage layout**
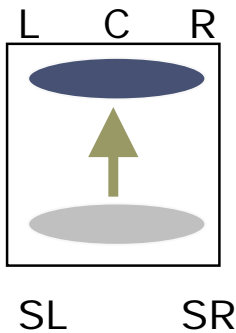
The main music components are positioned in the front section, while spatial information, such as reverberation of the hall and indirect acoustic components, are reproduced in the rear.

- **Discrete layout**

This layout is not intended to reproduce theatrical performances, but is suitable for the musical representation of something unrealistic by actively using more of the assigned channels. It is aimed at the front section but reproducible sound can be laid out freely over the audience's surroundings.

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Omni-directional layout
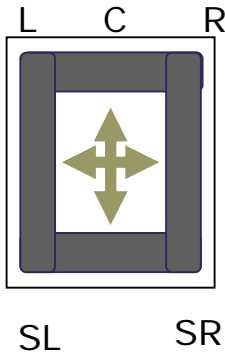
The audience's front axis is not fixed, so that they can receive the sound from all over. Musical artists, such as Japan's Isao Tomita and Britain's Allan Parsons, have created 'sound walls' by making good use of such omni-directional acoustic space.

4.3 Dialogue recording

Since dialogue accompanying images is positioned in principle, in the center channel, it may be recorded as monaural even when recorded on the spot. We sometimes record dialogue in the L-R channels or in the front L-C-R channels. When we want to stress the voice, we record it as monaural, and then we process it in post production. Dialogue spoken in a crowd scene or party scene in which the voice has to generate a sensation of expanse is recorded in stereo as material to be processed in post-production.

Sound collages and dialogue used as special effects may be positioned in accordance with producer's ideas.

The choice of microphone depends on the sound design. Sometimes we use stereo microphones and sometimes monaural ones.

We usually finish recording dialogues for a fifty-minute radio drama in one day.

The five pictures bellow illustrate how we record dialogue.

- **Dialogue recording microphone - basic stereo 2ch miking**
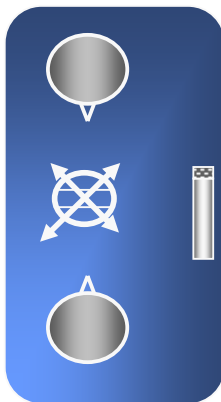
This is a basic microphone array for a radio drama. We put two figure-of-eight microphones on the same axle. This is how the left and the right channels. This system is called XY microphone.

Actors stand face to face with the microphone between them to record dialogues. We use a cardioid microphone for monologues.

- **Dialogue recording microphone - front 3ch miking**

  This is a front- 3ch microphone array for a surround sound radio drama.

  We put two figure-of-eight microphones on the same axle. When we pass them through MS circuit, we can record the L-R channels. Usually we record dialogues with only mid microphone at the same time and place recorded dialogues at the center channel. Now we are exploring recording dialogues using three channels, the L-C-R channels. I believe we can have a good result.

- **Dialogue recording microphone - illusion or non-specific localization miking**

  I sometimes use a dummy head microphone for recording illusion or non-specific localization of dialogues.

  When I put a figure-of-eight above a dummy head microphone, I can get a phase difference between a feigure-of-eight and a dummy head microphone. We can get voices from non-specific localization even when they are played back through loudspeakers.

- **Dialogue recording microphone - walla or group voice miking**
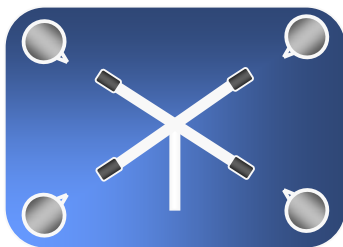
  This cross bar is called IRT-cross. Four microphones are placed at the corners of a 21-cm-square.These are CCM-4 Schoeps cardioid microphones.

  We record walla or group voice by IRT-cross on four tracks, the L, R, SL and SR channels. We add library materials to recorded walla, and we create surround sound.

- **Dialogue recording microphone - spaciousness sound miking**
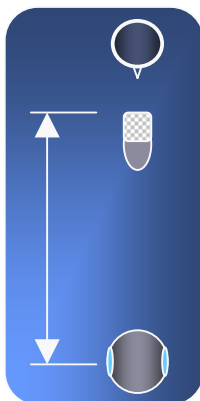
  This is a microphone array for recording dialogues to create a church scene.

  We recorded this at a music recording studio, CR-505 to record sense of distance and reflected sounds.

  The main microphone is figure-of-eight. We put a sphere microphone, KFM-6, backwards in the studio to record ambience. We assign the outputs of the sphere microphone to the SL and SR channels.

4.4 Dialogue editing

The production procedure after recording dialogues is editing.

We use the DAW(Digital Audio Workstation), made by Fairlight. The director edits dialogue recorded onto a hard disk, usually finishing 50 minutes of a surround-sound radio drama in five days, whereas 50 minutes of a stereo radio drama takes three days.

4.5 Foley recording

Foley may be in principle recorded as monaural because it is positioned in the center channel. It is recommended that the material be recorded in three L-C-R channels and processed if a sensation of expanse, like doors being fully opened over the whole screen, is required. To use the material for special effects, it can be positioned so that all the channels may be used efficiently. Basically, the front speaker configuration for sound effects may be any L-C, C -R, or L-R combination, while the rear alignment may be SL-SR, SL only and SR only. The size of sound image and the sensation of expanse should conform to image shots.

We usually finish recording foley sound for a 50-minute radio drama in one day, too.

4.6 Field location recording

We occasionally record field location for radio dramas. But we think it's important to do so far surround sound as well, because we have to increase the number of surround field sound libraries. We definitely record field location for surround sound for feature documentary programs.

Devices for surround field sound recording are quickly being equipped with various advanced functions. Audio equipment makers have developed new devices one after another. Key points in field location recording for surround sound are as follows.

- We need light equipment.

- The equipment must be simple to set up.

- We need portable multi-channel recorders.

- We want to be able to do surround monitoring with headphones.

- We want simple access to PC or DAW.

- These must be mechanically stable and reliable.

4.6.1 Four channels or five channels?

While four channels are sufficient to record surround field location sound for feature documentary programs, five-channel recording is recommended when a stable field location sound is needed or when recording sound for which hard center positioning should be used, such as interviews, with surround field location sound. This conclusion is supported by the results of the subjective listening testing we performed to compare the effectiveness of the above two methods.

In my opinion, five channels should be used for recording. Because five channels create superior sound connection in the front channels. You can achieve a balance by leveling down or cutting center channels when dialogues are poorly-heard.

4.6.2 Portable multi-channel recorder

At NHK, we usually do field location recording for surround sound with the Fostex PD-6 portable location recorder. This battery-operated recorder allows 6-track recordings on DVD-RAM. It can run for 2.5 hours on a lithium battery. We can record 5-channel tracks on both sides of a DVD-RAM for 40 minutes when we set the sample frequency at 48KHz and the quantization bit rate at 16 bits.

We also have a DEVA, made by Zaxcom, the US manufacturer, that developed a 4-track hard-disk recorder designed primarily for motion picture sound recording on location. This new multi-track recorder was launched to meet the needs of users who require more than 4 channels up to 10 tracks.

4.6.3 Field recording microphone

Next, I will show you five pictures depicting field location recording using ingenious miking.

- **ORF Mr.Florian Camere's 5ch human miking**

This is Mr.Florian Camerer of ORF(Austria Broadcasting Corporation). He is recording field locations with 5-ch microphone array. On his shoulder are three 2-ch portable DAT recorders for surround sound recording, with synchronized timecodes. This requires physical strength.

Mr.Florian Camerer's 5ch human miking is based on INA-5 (a microphone array for surround sound).

- **5-m-square miking**

This is a 5-m-square microphone array. Four CCM-4 Schoeps cardioid microphones are placed at the corners of a 5-m-squre.

I think this microphone array is better than a one-point microphone array for providing spatial impressions through surround sound.

- **IRT-cross**

This is an IRT-cross. – an arrangement of 4 microphones crossing each other to make an X shape. It is used to record good ambient surround sound. When we put an IRT-cross at a height of 3m, we can get good sounds.

- **Sanken CUW-180+CS-1 one-point 5ch miking**

This is one-point miking with two Sanken CUW-180 microphones and a CS-1 microphone in a basket-type windscreen. We are ready to record sounds with this one-point 5ch miking because of compact mobility. We can get high-quality sound and sound from specific localization with this miking.

- **Umbrella 5ch miking**

An audio mixer at NHK ordered a craftsman to make a fiberglass umbrella-shaped microphone boom pole. He put five CCM-2 Schoeps omni-microphones at each end of the ribs of the umbrella-shaped boom pole. Each microphone distance is 80 cm.

4.7 Scoring music recording

If we decide the sound design for scoring music, we must choice miking for surround sound music. We usually finish recording scoring music in surround sound for a fifty minute radio drama in one day. Some famous surround microphone arrays are listed below.
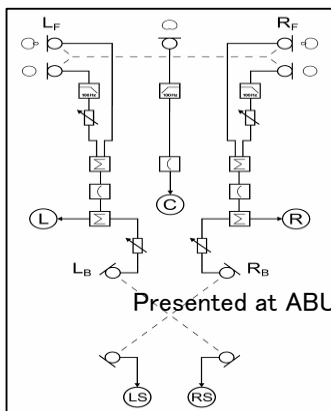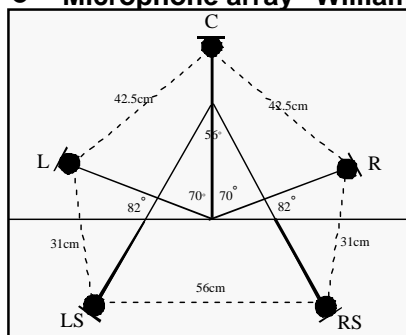

- **Microphone array "OCT + IRT cross"**

The OCT array uses super-cardioid to make the front position clear.

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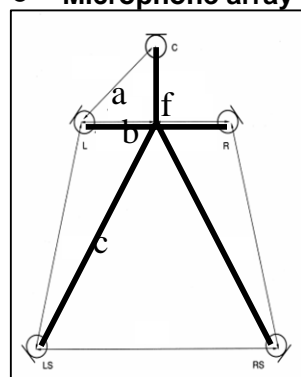An omni-directional microphone cuts the high frequency.

The unidirectional microphone is arranged in a cross shape and IRT catches ambience.
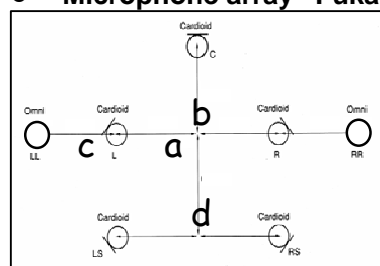
- **Microphone array "Williams"**

Williams shows how to find optimum value in terms of microphone distance; he first decides the recording angle, where it faces, and the microphone angle.

- **Microphone array "INA"**

This setup is designed especially for playback through a 3-2 loudspeaker setup, including the surround speakers. Five microphones are employed in exactly the same positions as where the speakers are supposed to be. Only the radius, and hence the distance between the microphones, is smaller. The microphones used are cardioids. They face "outward", or in exactly opposite to the direction that the speakers are facing.

- **Microphone array "Fukada tree"**

The Fukada tree is a microphone array by Mr. Akira Fukada, one of our outstanding recording engineers.

The model that acts as the base is decca.

It has two characteristics. Cardioid microphones are used as main microphones. Also two omini-microphones are used as LL and RR. I think that LL and RR microphones make a good combination for the front and the rear.
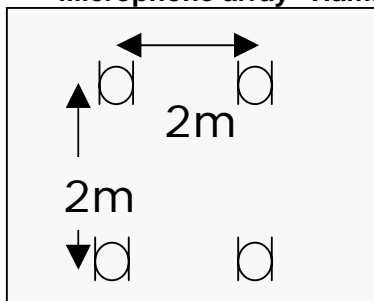
I like Fukada tree best, because of the spatial impression and the transparency of the sound.

This picture shows recording of surround sound music for the radio drama about atomic bomb victims in

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Hiroshima. The main microphone array, the Fukada tree, is put above the composer.

- **Microphone array "Hamasaki Square"**

The "Hamasaki Square" is named after Mr. Kimio Hamasaki, our outstanding researcher.

The array contains four figure-of-eight microphones mounted on a two-meter-square frame, with their nulls aimed towards the front and rear. Thus it is predominantly the side and interior signals that are captured, with little or no contribution from the direct sound to the front, or the 'slap-back' reflections from the rear wall.

4.8 Pre-mix

We usually finish pre-mix for fifty minutes of a surround-sound radio drama in four days, whereas fifty minutes of a stereo radio drama takes two days.

We should have knowledge of mixing on surround sound for a radio drama before pre-mix. That will surely lead to success.

4.8.1 Localization of sound elements
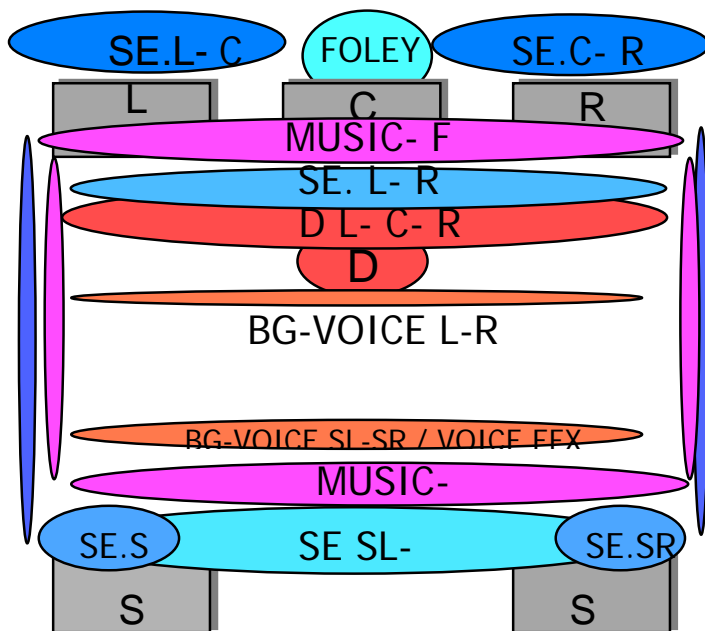
I stressed the importance of sound design before producing a surround-sound radio drama program. Next, I will discuss the localization of sound elements for surround-sound radio drama. This is a model for the localization of sound elements.

First, I will explain dialogue. The dialogue is basically placed at the center channel. If you want to stress the voice, you can place the main portion of the signal content at the

center channel, with processed portions distributed to the L, R, SL and SR channels.

Next, sound effects. Foleys are basically placed at the center channel. You must use all channels to create SFX. Basically we design sound effects in combination with the L and C channels or the C and R channels, or the L and R channels. And we basically design sound effects in combination with the SL and SR channels, or only the SL channel or only the SR channel.

Last is Music. The main portion of the score is basically placed at the L, C and R channels with ambience elements distributed to the SL and SR channels. Source music is basically placed at the center channel. We make use of all channels effectively when we create ME.

In this way we can create surround sound when we assign all elements to each channel. Then we mix these sound.

4.8.2 Representation of Center channel

Whenever we discuss surround sound, the center channel is always a hot topic. I will talk about the hard center, the phantom center and the combining

● **Positioning for the hard center**

This is used to clearly distinguish a real sound image from the images of other channels or when there is a need for an articulate sound image of center position, instead of a phantom center image. This has the advantage of allowing a mix-down using coefficients that approximately match theoretical values. This method helps stabilize overall positioning when used for the main vocals or a specific solo instrument as well as for narrations and monologues. Even sounds that are out of the sweet spot area would largely be kept in equilibrium.

● **Positioning for the phantom center**

As with the conventional 2-channel stereo method, this position is used to emphasize high-quality sound blending between the front L-C-R speakers or when no articulate sound image is necessary.

This is enough provided there is no pressing need to use the center channel, or if the speakers in the reproduction area have narrow intervals. It should be noted, however, that phantom center sounds would form a diffused sound image and would sound out of balance if the image screen size was 50 inches or larger, or if the L and R speakers were placed 2.5 m or more apart.

● **Mixture**

By combining the previous two methods, this approach sets positions by combining the specific hard center in the center channel and the supplementary phantom center between the L and R speakers. It is useful for smoothly blending sound images in the whole front together while articulately placing center components in position. For this

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purpose, cross talk between the L-C-R channels must be controlled using what is called the divergence function. Typical examples are as follows: for monologues, position the main sound in the hard center channel and in the L-R channels but with the level reduced by 3 to 4 dB, or avoid the risk of over-level by concentrating the bass and kick drum parts only in the hard center channel. The latter example requires special care in the mix-down to prevent any difference in the balance between surround sounds and 2-channel stereo sounds.

4.8.3 The LFE

We can express the feeling of terror or thrills or elation through the LFE. However, it is important not to rely on the LFE too much. If a loud LFE is on in one's home, the listener will turn the volume down. It becomes increasingly hard to hear dialogue in the drama. But if we don't create the LFE in the program, the number of complaints from listeners will increase. They'll say "We can't hear anything from our subwoofer speaker". I always design the scenes to utilize the LFE effectively and am careful not to make surround-sound radio dramas boring.

Heavy bass components up to 120Hz offer a useful means of representing motion-picture and drama sounds. Usually adding a slight flavor with a limited amount of heavy bass components is enough. It is a fundamental that you must achieve a balance in the L-C-R-SL-SR as main speakers. The LFE should never be used to carry the bass content of the main speaker channel. The LFE is a type of low sound effect.

4.8.4 Pro LogicⅡ

On the one hand, it is possible to broadcast 5.1-channel surround sound on digital TV, but on the other hand, conventional analogue two-channel stereo sound is broadcast on FM radio. NHK had adopted Dolby surround, which is matrix-surround encoding, on FM radio until a couple years ago. The Dolby Surround encoder receives four inputs signals (L-R-C-S) from the audio console and matrix to encode them into two output signals (Lt / Rt). The Dolby Surround decoder decodes two-channel encoded signals (Lt / Rt) into four output signals(L-R-C-S) using Dolby Surround Pro Logic decoding technology. In other words, the Dolby Surround makes the system a 4-2-4 system. This format has only mono surround and ignore the LFE channel. NHK has been producing 5.1-channel surround sound programs for radio dramas since we built a studio for 5.1-channel surround sound radio drama programs in 1997. Audio drama mixers at NHK have sought a surround sound encoding technology to enable the delivery and preservation of these 5.1-channel surround sound effects over NHK's two-channel stereo broadcasting system.

NHK selected the Dolby Pro LogicⅡ as our surround sound technology in 2004. This makes the system a 5-2-5 system. NHK has two reasons why we selected the Dolby Pro LogicⅡ as a surround sound matrix system. First, no licensing fee is required. Second, NHK's listeners with AMP for DVD don't need to buy new equipments for

surround-sound radio drama.

We can provide a listening experience that more closely resembles the discrete 5.1-channel surround sound mix of the Dolby Pro LogicⅡ. The Dolby Pro LogicⅡis backward-compatible with mono and stereo formats. Of course, mixers look for quality of compatibility with stereo because they listen through the encoder while mixing in order to hear any subtle changes that the Dolby Pro LogicⅡmatrix encoding process may create.

At the beginning of the radio drama, a narrator announces that the program is produced in surround sound. Listeners then know that it is a surround sound program, and can set up their surround sound system. NHK's listeners who have the Dolby Pro LogicⅡor another matrix surround decoder installed will enjoy a stunning 5.1-channel surround sound experience because of the compatibility with other systems.

Audio mixers should understand how the Dolby Pro LogicⅡ has changed the original discrete 5.1-channel sound. We have five points to note when we mix with the Dolby Pro LogicⅡmatrix.

- Sounds tend to converge on the center speaker.
- The Dolby Pro LogicⅡuses phase encoding of the surround channels. If the sound comes from the surround channels, the polarity is inverted in the Lt/Rt stereo downmix through the encoder.
- The decoder inserts delay time into the surround channels.
- The LFE channel is made from the low frequency in the L-C-R channels throughout the decoder processes, and the low-frequency bandpass filter inserts into all channels.
- Interior sound effects come from all five channels and appear to surround the listeners. The result through the decoder is the tendency toward convergence on the center speaker.

5. The global trend of digital radio

In Japan digital radio broadcasting for application test has started in Tokyo, Osaka in 2003. Radio broadcasters strongly desired the start of digital radio broadcasting for regular service before 2011.

I would like to mention the future of digital radio broadcasting based on the global trend.

Surround sound broadcasting is promoted in regions where digital radio broadcasting has already been started. Such regions vigorously discuss which system is the best for surround sound in digital radio broadcasting -- Dolby Pro LogicⅡ or SRS Circle Surround or Neural Surround. I pay particular attention to the MEPG Surround of these systems.

This new technology idea is quite different from the matrix surround system. In principle, a compact set of parameters representing the spatial image of the original discrete

5.1-channel surround signal is transmitted along with an automatic stereo downmix. On the decoder side, the transmitted stereo mixdown signals are expanded into a high-quality 5.1-channel output based on the spatial parameters as side information describing binaural cues / spatialization. The MPEG Surround features are as follows.

- Precise reproduction of the original discrete 5.1-ch surround sound, and multi-channel sound whose quality is significantly better than that of matrix surround systems.
- Very low bitrate representation of multi-channel signals.
- Full backward compatibility to mono or stereo.

We will be able to enjoy highly-reproducible surround sound with this new technology, so I foresee an explosive expansion of MPEG Surround around the world.

I think some broadcasters will select MPEG Surround as their surround sound technology if digital radio broadcasting starts in Japan.

6. Conclusion

NHK has many radio drama programs that are highly praised around the world because of our 20 years of experience and know-how in surround sound production. "The Sorrow of War", a 5.1-channel surround sound 50-minute radio drama program, won not only the ABU Prize for drama (radio) in Vietnam last year, but also the 2006 PRIX Italia Award for adapted radio drama.

We demonstrated 5.1-channel surround-sound radio drama at a hotel in Vietnam for the last ABU general assembly. That led us to decide on co-production of a radio drama program with VOV. This co-production is going on now. We also have ongoing co-production of a radio drama program with the WDR in Germany.

NHK is determined to promote overseas co-production and extend international technical cooperation with Asia-pacific countries. We can contribute to enhancing technical broadcasting capacity beyond national borders.

Finally I would like to emphasize these points.

- Surround sound is fascinating to us.
- Sharing know-how in producing surround sound is very important.
- In order to create good surround sound, we should take every opportunity we can.

I've decided to advance slowly but surely in continuing to create good surround sound.