WHY ARE THE MONITORS SO LOUD?

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Well the service is over and there were some visitors there today so you go shake their hands and tell them how much you enjoyed them coming today and hope they enjoyed the service. Of course they smile and tell you how much they enjoyed the music and the sermon but when they get to the car the first topic of conversation isn't how dynamic the sermon was but why was the music so loud how they couldn't understand any of what the vocalists were singing and why did it just sound so bad? These folks will probably keep shopping for a new church home. This one wasn't quite what they expected.

The above story may seem a little far fetched, but not really. Studies have shown that one of the main drawing points for new members to a church is what type of music the service utilizes and how good is the quality of the music. Not just the quality of the musicians and singers but the quality of the sound of the music when it gets to their ears. People today are accustomed to hearing high quality music wherever they hear it. Today's technology has brought the quality of music to such a level that people will not tolerate poor quality music. Compare the sound systems in cars today as opposed to a few years ago. Home theater with the HDTV is now the norm as opposed to the tiny speakers that used to come in TVs. You can now walk around with a high quality MP3 player and get quality music anywhere anytime. So why would we think that people will accept poor quality music when they come to worship. The answer is more often than not is they won't. With the choices people have when it comes to Churches today the sky is the limit. So why *did* the music sound so uninviting at the Church they visited? Maybe those floor monitors the praise band was using could be the culprit. Let's take a look at some of the common problems associated with using monitors, some physics and some things you can do to keep the monitors and the stage volume under control.

First off let's start with some basics. How do we hear and how do we discern the difference in things we hear. There is something called signal to noise ratio which in simple terms is the ratio of something called the signal which is the sound you are trying to hear to the noise level which is everything else you hear which is not what you are trying to hear. An example is trying to watch the big game on TV and someone fires up the vacum cleaner. The TV audio is the signal and the vacum cleaner is the noise. If you can't hear *and understand* the TV audio because of the vacum cleaner you have a poor signal to noise ratio. We will use dBSPL to express the ratio. Sound level meters will usually have a setting for "A" or "C" weighting and "slow" and "fast" response. We will use the A weighting scale and slow response for our purposes. The A weighting adjusts how the meter reacts to different frequencies to closer match how we perceive different sound levels by frequency. We can express this in dBA. A difference of 3dBSPL is a noticeable difference but not much. A difference of 6dBSPL is about half again as loud. And a difference of 10dBSPL is about twice as loud. So how do we improve the S/N ratio? We either make the signal louder of the noise quieter. The answer is of course to grab the remote control and turn up the volume on the TV. Notice it says hear and understand. Listening for information is different than casual listening. Casual listening is what you do for most music listening. You usually already know the song and you are just listening for enjoyment, like having the radio on while you work. When you listen for information things are very different you are more focused to gather precise information such as words or for a musician timing and pitch among other things. The S/N requirements are very

different also. For casual listening we really aren't concerned about the S/N ratio because we aren't trying to discern specific information, just enjoying the music. On the other hand, we would like a S/N ratio where the signal is 10dbSPL louder than the noise level to easily discern information. That is to say what you are trying to hear needs to be *twice* as loud as everything else to easily discern information. Now what does that have to do with the bands monitors? We'll get there soon but first some more physics.

Let's look at some room acoustics. Whenever you inject sound into a room depending on many variables the sound will bounce around at about 1130 ft/sec or about 1ft. per millisecond until the sound is absorbed. Sound is made up of many frequencies and they all don't get absorbed at the same rate. In most rooms the lower frequencies will decay and a slower rate than the higher frequencies. What does this mean? When you inject sound such as music into a room the bass frequencies will hang around longer than the higher ones and, depending on the room, can cause the overall sound to be muddy and hard to understand. The less bass that you put into the monitor mix the better things will work. Another factor is the average time the room holds the sound energy before it is absorbed. When people talk about a room being "hard" or "dry" they are referring to the cumulative spectral decay of the sound energy in the room. Fancy words that mean how long on average does it take sound to "fade" away. This is important because longer it takes the sound to decay in the room the lower the intelligibility of words will be. It will make the congregation sound better when they sing but everyone will have a harder time understanding spoken or sung words. But what does this have to do with the monitors?

OK, armed with a little physics let's look at how some of this applies to the bands stage monitors. Let's use a typical praise band as an example. We have a vocalist on keyboard. We'll call her Sue. We have a vocalist on lead electric guitar. We'll call him Bob. We have a female vocalist that we'll call Amy. We have another guitarist that also sings we'll call Joe. We've got Dave on bass guitar and Mike the sound guy. So the praise team sets up for a service and gets ready for a sound check and another struggle with the monitors. Now let's take a look at how they setup. All of the guitar players have set their amps behind them on the floor and the keyboard is on a direct box and all the vocalists have mics. Since this is a small church with limited funds all they have is a couple speaker wedges and the ability to get a single mix off the console for the monitors. So let's see what happens when they try to get a useable mix in the monitors. First Mike turns up the keyboard till until sue can hear the keyboard in the monitor so she can hear over the guitar amps on stage and then they start bringing up the vocals in the mix. Mike starts with the lead vocalist. He turns him up till he says "That's OK." And then proceeds to work through the vocalists. Now the band fires up the first song and all of a sudden Sue says "I can't hear the keyboard!" and all the vocalists are complaining that they need turned up in the monitors and the guitarists are reaching behind themselves and turning up their amps. So Mike turns everybody up a little and they try again and the same thing happens! Nobody is happy with the monitor mix and they keep telling Mike to turn them up. By now innocent bystanders are looking at Mike and yelling at him to turn it down but he can't hear because the monitors are pushing 100dbA and he hasn't even turned on the main house speakers yet! The band isn't happy with Mike. This is just a simple monitor mix. Why can't he get it right? Mike is

wondering why everyone in the band says they can't hear. They all must be deaf! People in the next town can probably hear it. So now we have some friction between the praise team and the sound guy. So after a while they finally get a mix that everyone says they can live with but just not happy with. Probably because the service will start soon and they don't have time to mess around with it any more. Sooooo the first song starts and Sue is still having trouble hearing the keyboard so what does she do? Of course, she pushes up the output a little so she can get just a little more keyboard in the monitor. But what really happened was. Sue does not have enough signal to noise ratio to discern information about the keyboard so she will do whatever she can to increase it. Now she doesn't just get louder in the monitors but also in the main mix so Mike brings her down in the main mix. But nobody can really tell because the monitors are so loud that the main mix is being overpowered and it sounds so bad he doesn't know what to do. In the mean time all the vocalists are pointing at the monitor and sticking their thumbs up while giving the "What happened?" look to the sound guy. So Mike tries his best and gives everyone just a little more of their vocals in the monitors and realizes that the monitors are on the verge of feeding back so he stops but they still want more. Then Amy moves closer to the monitor to hear herself better and now the monitors start howling with feedback because the volume was so high. Then they all give Mike the "look" that musicians give sound guys when the sound guy can't change the laws of physics.

This story gets played out in churches every Sunday. But why? Let's use some of that physics and see if we can figure out what is going on. The first thing we need to understand is that the musicians and vocalists are not using the monitor mix for casual listening. They are using it to discern information. They are trying to hear something specific to their need, usually their instrument and their vocals. Now remember that signal to noise thing? Each person wants to hear what *they* need at a level at least 6dB louder than everything else, and preferably 10dB louder. So now we understand one reason why vocalists and musicians keep saying they can't hear themselves. But we now know that the real answer is not that they can't hear but that the signal to noise ratio of what they need to hear is incorrect.

Now let's look at some other things that are driving the monitor volume up. The guitar players set their amps behind them pointing towards the audience. Why? I am going to make a bold statement here. Guitar players do not hear with the backs of their knees! Let's take a look at what is happening when the amp is placed behind the musician. An electric guitar is an instrument that must have the amplified sound sent to the musician for them to be able to play. The easiest way is to just stand in front of the amp and turn it up until the signal to noise ratio is what the guitar player wants. But wait a minute….. the speaker in the amp box is about 4 feet below his ears and not pointing at his ears its pointed about 90 degrees away from his head but the floor wedge about 7 feet away *is* pointing at his head. This means that whatever is coming out of the monitor is for the most part noise and he will turn up the amp till he hears his guitar. If the monitor is at 90dBA at his ears he will turn up the amp till his guitar is around 96-100dBA at his ears. Now remember the amp speaker is 4 feet from his head and pointing at the audience not his ears. Well, now you know why the guitars are so loud. And what about Mike the sound guy? Since he does not have control over the sound level of the guitars he is really not in control of the main mix. He must try to mix to match the level of what he can't control so if the guitar

is way too loud he either plays everything too loud or keeps the level down and whatever he can't control will just be too loud and make for a bad mix. I am going to make another bold statement. The sound guy needs to have control of everything the audience hears. If the sound guy doesn't have control then he goes from "artistic" mixing to damage control and a salvage operation. While we're here I'll make another bold statement. You can't tell what the main house mix will sound like from the monitors. Monitors are not meant to replicate the house main mix. Monitors are for providing information musicians and singers need to perform. Not to judge how it sounds to the audience. Sound techs need to trust the performers and the performers need to trust the sound techs.

What else is causing us problems with the monitors and also causing the main mix to sound so bad? Let's look at that speed of sound thing and see what it has to do with it. Sound travels at approximately 1 foot per millisecond. So when we blast a bunch of sound out of the monitors that are facing up and back the sound bounces off the back wall and the ceiling and then out into the audience area. On the average stage this could be a distance of 40 to 60 feet which means the monitor mix is 40 to 60 milliseconds behind the main mix and this doesn't even take into account all the other reflections the monitor mix makes before it spills into the audience area. But what harm can monitor spill make? Isn't it the same sound? Well, not really. That time difference will smear the incoming sound image that the audience hears and that will lower the intelligibility or how well we understand what is in the sound we hear. So if the monitors are so loud that there is a lot of spill from the monitors the sound quality the audience hears will be degraded. The main house speakers need to be around 10dBA louder than the monitors to be louder than and overcome some of the problems caused by the monitor spill. If the monitors are running at 95dBA the main house speakers will need to be at 105dBA. This is really too loud! Also remember that the lower frequencies will decay at a slower rate than the highs so all that bass in the monitor mix just adds to the problem because the longer it takes sound to decay the more reflections you get and the less intelligibility you get. I'll make another bold statement here. Microphones are not prejudiced. They will convert any sound that strikes the element into electrical signals. What? It means all that sound coming out of the monitors will, to some degree, bleed into any microphones on the stage. But you are using cardiod microphones and as long as you point them away from the monitors they won't pick sound from the monitors. Right? Well, not exactly, cardiod type microphones are less sensitive to the rear than they are to the front but when the stage volume gets to be really loud the sound is still getting to the mics and then is sent to the monitors and the main mix. Just because the monitors are not howling with feedback it doesn't mean that sound from the monitors isn't bleeding into the mics. This lowers the intelligibility of both the monitor mix and the main mix. Try this little experiment sometime. When the band is fired up with that loud monitor mix have one of the singers stop singing and solo that channel to some headphones while everyone else keeps playing and singing. Whatever you hear in the channel is going to the monitor mix and the main mix. While we're talking about microphones another common problem is that the sound guy has the vocal mics up as loud as he can get them in the monitors without feedback. Of course the mics are on stands but then one of the vocalists decides they need to hold the mic. All goes well until they move forward or lower the mic or change the angle. Of course the feedback is the sound guy's fault and when he turns them down in

the monitor they are upset because they can't hear themselves now.

Now that we have looked at some of the things that cause problems let's look at some of the things that can be done to help. First and most important is that everyone must check their ego at the door. When anyone is involved in a worship service it is not about them. It is about *Him* and the worship experience of the congregation. If you do not have the heart of a servant then you should not be behind a mixing console or on stage. It is about doing your best for the congregation's worship experience. Everyone will need to accept whatever compromises need to be made to make the worship experience the best it can be. Now what can we do to give the musicians and vocalists what they need and keep the sound guy happy too. Let's start with the keyboard. A keyboard player really needs to hear the keyboard well to play well. How can we improve the signal to noise ratio without raising the monitor volume. If we get the sound closer to the keyboard player ears we need less level to sound louder. If we split the keyboard output between a small self powered monitor such as a Galaxy Hot Spot on a microphone stand and the mixing console the keyboard player now has what they want. Control over how loud they hear the keyboard and when positioned near their head they need less sound level and the sound guy can put just enough in to the monitor mix so the rest of the team has what they need. That was an easy one now let's move on to the guitars. Our guy Joe is a gadget guy and has a new amp modeling preamp so we can just get rid of the amp and just plug it into the mixer and turn his guitar up in the monitors. Right? Well Joe needs to hear his guitar over everything else. That signal to noise ratio thing again. So what can we do to get Joe's guitar loud enough for him without cranking the level of his guitar up in a speaker 6 feet from his head? We can use a microphone stand mounted self powered monitor like the keyboard but some guitarists don't like that sort of sound. Some guitarists like a small headphone amplifier and an earpiece. Either way it puts the sound they need closer to their ears and helps hold down the instrument volume in the monitor mix. This brings us to Bob and he isn't going to give up his amp. It is part of his sound and he isn't about to use one of those modeling gadgets. With many guitarists their amp *is* part of how their guitar sounds and taking the amp away isn't an option so can we find some kind of compromise that works for everybody? One of the simplest things we can do is to place the amp cabinet in front of the guitarist at a 45 degree angle and then tilt the cabinet back so the speaker is aimed at the guitarist's head. What will this do for us? By setting the amp in front and slightly off to the side and angled and tilted back we put more of the sound at the guitarist's ears and less going out into the audience. Since a lot of sound comes out of the back of an open back guitar amp setting it slightly to the side of the guitarist and angling the cabinet we can prevent some of the sound coming from the back of the cabinet from spilling into the audience. But what do we do to get the sound of the amp into the sound system? We mic the amp. Use a cardiod pattern microphone placed directly in front of the amp cabinet speaker. The guitarist can turn the amp up until he has just enough to be able to play and with the cabinet mic'd the sound guy now has control over what goes into the monitor mix for the rest of the musicians and also the main speakers. The catch to this is that once the level of the amp is established the *level must not change!* If the guitarist "tweaks" the volume up even just a little it can ruin the monitor mix and trigger a round of "monitor wars." Remember, the sound guy can't

hear changes in the monitor mix so if something changes he won't know it.

Building a good useable monitor mix is not as simple or as easy as folks would like to think it is. It is not saying "test test one two one two" and strumming a few chords to see if you can hear the monitor. If you ask ten sound guys how to setup a monitor mix you will get ten different techniques. Everyone has their own way of doing it but I will give some suggestions for building a monitor mix when you only have one mix. The first thing to consider is time. It's hard but everyone must show up and be ready to do the sound check with adequate time to establish the monitor mix the house mix and EQ on the channels. It is unfair to the sound tech for musicians to show up just in time to tune up and expect to do the sound check in five minutes. And it is unfair of the sound tech to not be ready for the musicians when it is time for the sound check. OK, we have everybody ready plenty early so let's setup the monitor mix.

One of the first things we need to consider is what is the maximum allowable sound level of the monitor mix. For this you will need a sound level meter. You can purchase a reasonable meter for about $100 or a lesser quality one for less at your local electronics chain store. Even a low end sound level meter is better than none. So what should the maximum level be? That depends but a rule of thumb is the louder you are going to run the main speakers the louder you can run the monitors. But less is always better. Let's say that we expect to run the main speakers at about 90dBA when the band is cranked up so if the monitors are at 95dBA we have a problem. The spill from the stage will be louder than the desired house level and probably not the best sounding mix. So if we set a target maximum SPL of 80dbA we will still have stage spill but since it is lower than the house level it will work. The goal is to get the lowest level possible on stage but when using floor wedges for a band rocking the house a low level is probably not going to happen so we set a target maximum and work within that. We also need to remember that the closer a sound is to a person's ears the lower the level can be and still have the same SPL at their ears. And that guitar players hear better with their ears and not the backs of their knees. Now let's go back to our praise band and see if we can do little better with the monitor setup.

Since we caught the finance committee in a moment of weakness and they let us purchase a self powered Hot Spot monitor for the keyboard player we will split the output of the keyboard between the Hot Spot and the mixing console and position the Hot Spot close to the keyboard players head. So now Sue has what she needs and the sound guy has the ability to control the keyboard in the monitor mix and the house mix without affecting the keyboard player. Now since Joe is using a guitar amp modeler he doesn't really need a full size amp cabinet to hear so he decides to use a set of open back headphones and a small headphone amp with the output of the modeler split between the headphones and the mixing console. He could have also used a small amplified monitor like a Hot Spot but the headphones were cheaper and they worked for him. Not all guitar players are the same so you have to find what works for them. We move on to Bob and he's not giving up his amp so what can we do? We don't want to just split the output of his guitar between the amp and mixing console because we will lose what the amp and speaker does for the sound. So we need to get the sound of the amp closer to his ears. Place the amp in front of Bob slight off center and angle it back so it is pointing at his head and then place a cardiod mic of your choice in front

of the amp speaker. Bob now sets the level of the amp to just what he needs to play and Mike, the sound guy, has the ability to adjust his guitar in the mix and the house without changing the level Bob hears. But it is very important that Bob not change the level of his amp once the sound check is done because if he does it will change the signal to noise ratio between his amp and what everyone else hears so it starts the chain-reaction monitor wars. Remember it is about what we need and not what we want. But wait, Bob has spent too many of his younger years in a rock band and is still having trouble hearing his amp and keeping the level low enough to make this all work. Bob needs more signal but this will make his amp too loud for everyone else. What can we do? We need the sound closer to his ears so we find a small table about two or three feet tall and set the amp on it tilted back facing at Bob's head. Bob gets an increase in sound level and we didn't need to actually turn the amp up so we are still on track to get a monitor mix that will work and still be low enough to work with the house speakers. We have Dave on the bass so what do we do with him? We could mic his cabinet the same way we did Bob's but since this is a fairly small room we'll just have Dave just setup as usual and play. Since the bass frequencies are much less directional than the higher frequencies aiming and tilting the amp would have much less effect. If this were a larger room we would probably mic the cabinet. So now we have all the musicians play and set their level to the minimum they need to be able to play. Not as loud as they want it, just what they need. Now mike gets out his sound level meter and sees just how loud it really is. Hopefully we are below our target maximum level and since our target max was 80dbSPL and we are at about 77dbSPL things are looking good. But the musicians say that they can't hear the other instruments now. So we can now bring up the instruments in the monitor mix enough that the musicians and vocalists can hear the other instruments but we haven't changed the level the musicians hear from their own instruments. We still need to be below the target max level.

Now that we have the instruments set let's move on to the vocalists. Again if you ask ten different vocalists how they want the monitors set you will get at least ten different responses. As with most everything in live sound it all depends on many different things so you keep trying different things and different ways. This is how you gain skill and experience. Here we are just going to do a simple vocal mix because we only have one mix. We will start with Amy because she is the lead vocalist we have the musicians play and Amy sing and slowly bring her up in the mix until she has what she needs. This will vary among vocalists. Usually the more accomplished the vocalist is the less they need to hear themselves to sing. Not trying to throw stones here it just sort of works out that way. We then work our way through the vocalists. At the end we will probably need to do some tweaks but don't fall back into the "I need more me" thing and just start turning things up. If someone just can't hear enough of something look for alternatives to just twisting the knob a little more. If you have a vocalist that just has to hear them self at 20dB over everything else get them a personal monitor amp and some earbuds so they can get them self as loud as they want without getting the monitor mix above the target max. Something like a Rolls PM50 will allow you to monitor a microphone and a line level monitor mix and adjust both independently. Getting a good monitor mix is as much art as it is science. As long as we get a monitor mix that is about 6-10dbA lower than the level we expect to run the house level at things will work but if we can get the stage level even lower the better

the house will sound. Well everything has gone pretty good and we have a monitor mix that everyone can use and still have the stage sound level low enough that we can actually use the main house speakers and now we can start adjusting the sound for quality and not just doing damage control.

So now the church has found a few more dollars for the "sound stuff" and everyone wants to get more stuff so they can all get their own monitor mix. Before you go out and buy some more amps and wedges and put a monitor in front of each person and give them their own mix be aware that sound doesn't come out and only go to the person you want it to and not someone a few feet beside them. The lower the frequency the less control the speaker has over the coverage pattern. Let us say you line up four singers across the stage about three feet apart and give them all a monitor with their own individual mix. So you start setting up the monitors and people keep saying they can't hear their monitor and to turn it up. But wait; didn't we just fix this problem by giving everyone their own mix? A closer look may tell us what is happening. We have four speakers that are three feet apart pointing up at heads that are about six feet away. So the sound from the speakers is spilling onto the other singers besides the one it is intended for. Remember that signal to noise thing? The mix they want to hear is the one in their monitor but it needs to be at least 6dB louder than the other monitor mixes. So everyone is actually saying is. "I need a better signal to noise ratio to be able use my monitor. Please increase the level so it is at least 6dBA and preferably 10dBA louder than the other monitor mixes which are noise to me." But since all the singers have the exact same problem what is the solution? Let's go back to the physics. It is all about the signal to noise ratio. You need to either lower the noise or increase the signal at the person's ears. One way to do this is to put more distance between the singers so that the speakers are further apart. Might work well if you have a fifty foot wide stage to work with but what would happen if we moved the speakers closer to their heads? We could set the speakers on step ladders and position them right next to their heads. That would fix the signal to noise problem and we could also turn the level down a lot because the sound source is now inches away instead of six feet. But somehow I don't think this will be practical. What else can we do? Since we have the source so close to the ears we can use a smaller speaker and amplifier but the singers are stuck in the same spot by the step ladder because if they move a little bit it my not be loud enough. We could fix that by hanging the speaker around their neck. They can move around now without the level of their monitor changing but I still don't think they will go for it. Now what? Why don't we get rid of the speaker and use a set of earbud headphones with a real small amplifier. Now we have the sound source at the ear and the output level is so low that causes no noise on the stage and the singer gets what they have always wanted, the ability to control their own monitor level. We have solved the signal to noise ratio problem by moving the sound source closer to the ears and lowering the level. There are many personal headphone amps available. An example is the Rolls PM50. So before you go out and start buying more amps and wedges consider headphones and headphone amps or small personal monitors like the Hot Spot. Trying to run multiple monitor mixes on a small stage can sometimes be more frustrating than a single mix because everyone wants theirs louder than the one next to them and now we are back to "monitor wars" again.

This paper is not intended to be a comprehensive end all to stage monitors but rather a layman's primer to the basics

and some of the science. For every situation there are different ways to approach it but if you have some knowledge of the science behind it you have a better chance of fixing it. One of the problems I almost always encounter when working with churches is the monitor system for the musicians and singers. With so many churches moving to a more contemporary worship style most struggle with the monitors and they usually end up being way too loud for the space. Just because you see them do something on TV or because "it's the way all the bands do it" doesn't mean it's the best way.

The table shows dBSPL relative to some example sounds. Remember that a 10dB increase will result in the sound being twice as loud. So and increase from 90dB to 100dB is a *significant* increase. Remember, it is about the worship experience of the congregation.

Sound	**dB-SPL**
Jet engine at 3m	140
Threshold of pain	130
Loud rock concert	120
Jet aircraft at 100m	110
Pneumatic hammer at 2m	100
Noisy factory	90
Vacuum cleaner	80
Busy traffic	70
Quiet restaurant	50
Residential area at night	40
Empty movie house	30
Rustling of leaves	20
Human breathing (at 3m)	10

Things to remember

- **Signal to noise ratio is very important.**
- **One person's signal may be someone else's noise.**
- **The closer you get the signal to the ears the less volume you need to maintain the sound level at the ears.**
- **Guitar and keyboard players don't hear with their knees.**
- **If the monitors are louder than the house mix it will sound bad.**
- **Set a maximum level for the monitors and stick to it. Don't escalate into "monitor wars"**
- **Sometimes the answer is to turn something else down to make something appear louder.**
- **It's not about the performers, it's about the performance.**