

INTERVIEW WITH ARTHUR SAUER

[Transcription of the interview recorded in The Hague, the 17th July, 2012]

Ángel Arranz: Tell me please about the history of Wave Field Synthesis.

Arthur Sauer: Wave Field Synthesis [WFS] was invented in 1988 by Professor Berkhout¹. I heard of it from my acoustics teacher at the conservatory, Diemer de Vries. Originally it was called something like holographics, and there was a patent pending about changing acoustics of halls. It could be used for changing the acoustics of halls, so they would become suited for doing church organ music, orchestral music, speech or whatever. This I know from the original article about WFS published in the Journal of the Audio Engineering Society. I have never looked at the patent though. Diemer is actually the one who continued researching WFS. I think Berkhout was more occupied with seismology. When I heard about this system I thought 'Well, if you can make virtual acoustics with it, you can also use it for electronic music'. I have always been interested in multichannel speaker systems. Actually, when I was a little kid, I used to build speaker boxes from speakers I found at the garbage. I used to go out to collect every radio or television I could find and take its speakers out. Then, I used large cardboard boxes and fitted them with all these different kinds of speakers in all sizes all around the box. I also attached on/off switches to the different speakers so I could change the sound. Often I took my mother's radio and used it as an input for the speakers, and then played with the different sounds.

AA: So, the role of Diemer de Vries was important for you.

AS: Yes, he is the one who told me about the system. This was around 1988. In 1988 computers were not powerful enough to build a WFS system. I think at that time I had an Atari 1040ST computer. I invested every cent in equipment, so, there was my Atari and, of course, an Atari is not powerful enough to build a system like we have now. I think you would need an Atari per speaker, so that would be a hundred and ninety-two Ataris...

AA: With 1 MB information storage...

AS: And even then I am not really sure how you could do it: that would really mean distributed processing... we were not there in 1988. So, I put it in the back of my mind that someday it would be nice to try to build such a system.

In 1999 Erwin Roebroeks asked me to propose a project that he could organize. I met Erwin through the editorial board of a magazine that was called THD, a name I conceived because I thought it was a kind of cool title. It is actually an acronym for Total Harmonic Distortion. As I was into electronic music, I was asked to join the editorial board. The idea was to make a multimedia magazine with a CD-Rom inside, something quite new at that time. Since the subject of the magazine was electronic art in the broadest sense, and I had heard Erwin knew a lot about techno, I suggested that he should join the editorial board. So, this is how I met Erwin. Then, he invited me to do a project, and I suggested doing something with an 8-channel speaker system and the idea of what 'going out' could be in the 21st century. The project was called 'The Game of Life'. We designed a tent that sort of looked like an igloo, and we had special trusses built for the speaker system, so we had our own mobile stage!

¹ Berkhout, A. J.: A Holographic Approach to Acoustic Control, *Journal of the Audio Engineering Society*, vol. 36, December 1988, pp. 977-995

AA: What was your perspective as a composer in that first musical project?

AS: I have always been interested in working with speakers in general. Speakers are the instruments of the electronic music composer. When Erwin called me, I was really into techno music and danceable stuff, in my own idiosyncratic way, so I was thinking about what going out in the 21st century could be. I thought that techno, as an abstract form of electronic music and the use of multi-channel speaker systems were good ingredients for creating environments for going out. I kept it simple by using an 8-channel speaker system and implementing it as a 3D system. Every system I heard about until then was circular, the so-called 'Stonehenge deployment'. So, I had three speakers at the bottom, like a triangle; then one higher triangle, but rotated by 60 degrees; finally, one speaker system in the top of the tent and subwoofers on the floor. I had a very short time to compose for it, because the organization in charge of producing the event was at the point of bankruptcy. So I had around ten days to perform a concert of one hour with new software, new hardware, 8-channel speaker system and having to write music for that. It was like non-stop working. That is how The Game of Life project got off the ground.

AA: So, the impulse was that.

AS: Yes, but there was a bigger idea with the tent as well, because we invited other people in the tent. In the afternoon we had for instance trumpet player Marco Blaauw playing Stockhausen, and after my concert we had DJ's like The Asian Dub Foundation, DJ Eva at 18 years old DJ'ing Techstep, a heavy form of Drum 'n' Bass, which I think was one of the best evenings we had. It is important to realize that an audience does not necessarily go to a concert for the music. I think the atmosphere of a place is even more important than the exact music that is being played. Of course the environment should also fit the music. The nice thing about our tent was that it was a completely anonymous structure. It looked more like a UFO than like a concert hall. We had rows of two hundred meters in front of the tent with people wanting to get in. One day the tent flew in a tree as the result of a short, but very heavy storm: that was the end of the tent.

After The Game of Life project had finished, we had some money left, so I proposed to do a project with a WFS system. Then we found out that Diemer de Vries was working at the Fraunhofer Institute in Ilmenau – you may know them as the inventors of mp3 [*laughs*]. It is something like a university with a research department that also makes money. We were invited to visit their laboratory. They also have a movie theater equipped with a WFS sound system. So, actually we could listen to two different systems. At the movie theatre they played a demo movie, which was an animation movie with a ship in a heavy storm. In the hold of the ship was a table with a vase on top. Because of the heavy storm the vase fell of the table and rolled from left to right. I watched the demo movie three times from three different places in the movie theater. In one place the vase was rolling through my head, it is really crazy to hear to something rolling through your head. And also it was crazy because the vase was in my head, but the image was on the screen. So, I felt something is wrong with using WFS for movies.

AA: It is a kind of dissociation between what you see and what you hear, in other words, about what you feel, is not it?

AS: Yes, it is named cognitive dissonance in psychology. To me it proved that the system was working. But finally the system was not fit for our purposes. The software was completely closed. We wanted to look at the data of their files and we had to sign non-disclosure agreements for that. The price was around 250.000 euros and we only had 60.000.

AA: And then you looked for alternatives.

AS: We investigated a couple of companies that could build a WFS system, but they were equally expensive. Then Wouter Snoei offered us to program the system in SuperCollider. We asked Raviv Ganchrow to design the speaker system. The software to sync two computers was written by Jan Trützschler. The estimated cost was like 105.000 euros. I did the technical supervision of the project to make sure everything worked out.

AA: *It was a kind of investment.*

AS: Yes, it was an investment by all the people who worked on the system, because we worked almost or actually for free.

AA: *I know basically what a WFS system is, however you may want to describe it a bit. On the basis of that description, why is WFS slightly different from other systems, what does it make it distinct?*

AS: WFS is a unique system, in the sense that, contrary to all other speakers systems, it does not work on the basis of perception, but on the basis of a reconstruction of what happens in nature. For instance, if you have a stereo, you have two speakers, and you can hear a sound coming from the middle between the two speakers. But this is strange, since there is not a speaker in the middle: what you should actually be hearing is two speakers making exactly the same sound. Our ears do not understand that, so they make a phantom image in the middle. That is perception, not what happens in a physical reality. The real thing is that there are two speakers making the same sound. Reality is that sound describes circles around these two speakers, which are interfering with each other creating complex interference patterns between the two speakers. WFS starts from a different point, which is reconstructing the wave fields in space. The idea for this system actually started with Christiaan Huygens in the 17th century, who wrote a book, *Traité de la Lumière* [Treaty of Light], where he demonstrated that light is a wave phenomenon. This started the debate in physics about light being a particle or a wave phenomenon. Huygens said that, if you look at a candle, you see that the light starts from one point: the candle. This light starting at the candle is moving out with the same speed in all directions. When everything moves out with the same speed in all directions you get a circle, so light moves as a circular wave. Let us observe how a Newton's cradle works: you pull out one ball, you let it strike the other balls and the last ball goes out. The balls in the middle do not move, which proves that energy can be transmitted from one particle to another. This was important for his theory: if light moves as a circular wave form particle to particle, then the waveform emitting from each small particle must also be a circular wave. So, if you look at the front of a wave of light, you would see that are many small particles emitting circular waves. If you add those sources up, then you get the circular wavefront again. This is the Huygens principle.

In the 19th century Lord Rayleigh said that if you reconstruct a circular wavefront with infinitely many small circular waves on the wavefront, you can also reconstruct this circular wavefront by using small circular waves on a straight line. We can even reconstruct the wavefronts in a volume: if we know all the things happening at the borders of this volume, we can reconstruct what is happening inside. Translated to WFS, the parallel is that each speaker is like a particle emitting a circular wave, and the array of speakers is the line where the individual circular waves of the speakers add up to a circular wavefront. Each speaker has a distance from the real source, so that means that there is a time that the wave travels from the source to the speaker, and while traveling to this speaker, the sound level decreases. So time and delay are all you have to know to make the calculation and restore a whole wave field inside a volume. Of course this theory of Rayleigh is all about physics. What professor Berkhout added was that if you can make these calculations for real sound sources, you can make them for virtual sound sources as well. It was like thinking a step further than his predecessors. Therefore, the basic theory of WFS is based on physics, not on perception.

There are still differences between the way our systems works and the way it works in nature: when you listen to a trumpet, the sound is different when the trumpeter plays with his front towards you or when he turns his back to you: in the second case you would hear less high frequencies. Our system can only play omni-directional sources. This means that we cannot turn the virtual trumpeter in our system and make him sound different when turning around. We are now trying to build these so-called directional sources into our system. The IRCAM has already done this, but they have done in such an incredible complicated manner that they can only do eight sources, and that with even more computers than we have. Our aim is to do it in a more practical way.

AA: I always thought that you people have created the system by using perception, instead of other approaches. When I imagined the WFS, I thought in the stereo way. But you certainly have demonstrated it is not like this: it is really about thinking what happens with energy, how to transmit the energy and how to calculate the delay in order to express the movement, is not it?

AS: Yes, it is so simple. There are many professors in the world, which could have invented this, since they were working all the time with wave equations. It could have been invented in 1910: nobody did. Of course this way of reproducing sound has implications for the perspective of the listener. We are used to concerts happening on a stage. We know where to look. They are over there, and we all look in the same direction. Some seats are more expensive than others, and the best seat is the most expensive seat. With WFS there is no best seat: all seats are equally good, though each seat still gives a different perspective on the 'sound stage'. As a composer, it means that you have to think in a different way. We are used to making a 2-channel mixes. We are going to sit on a chair behind the computer and we are going to set our levels, in tenths of decibels, in the way we think is the best. With WFS the level of a sound source depends on how close to the source you are: the closer, the louder. So, you cannot think about making [emphasizing] the perfect mix. There is not perfect rendition of the mix. You are making something for an audience that every member might have a different perspective on. Also it has implications for the way you compose, because you have to move away from this centralized genius idea of a composer to general, organized raw sound fields.

There is also another thing that affects to a certain kind of composing, which takes into account timing in milliseconds. Forget it with WFS, because 1 millisecond is 30 centimeters. Depending where I am sitting, this timing may be off like 10 milliseconds in a distance of 3 meters; it may be 300 milliseconds in a distance of 30 meters, and so on and so forth. The implication is that if you want to make the timing of your sounds with millisecond precision you have put all sounds in one spot, and it would be absolutely mono. So, you would have 192 speakers in order to do something mono... You have cheaper ways to do that! [with irony] It makes you think about tempo and timing in general (in academic electronic music there is not something that is called tempo), but you could start thinking about the gamelan kind of way, like having multiple layers with different tempi. This is something that works really well, because the sources are really separated. This layering of tempi sounds completely different in stereo. The tempi are more piled up in stereo and it is tiring for your ears to separate the layers if you listen to that too long. With WFS it is much easier for your brain, because you can locate a tempo layer here and another tempo layer over there. These are the kind of possibilities that the WFS system offers.

AA: As soon as the system evolves in time, since its birth in 2003 until 2006, in these three years there was a time in order to create the basics of the system.

AS: In those three years we were only doing hardware and software.

AA: So, one could say that in 2006 the system was at its very beginnings. What were the basic parameters of the system? Have you people added more features during those years?

AS: The system did not change much for many years. We have started version 2 of the software one and a half years ago. The first version of the software had to be built really fast. Wouter, who did the development, also had to compose a piece for the system, so we built a basic system that made it possible to realize pieces. If you were handy, you could also work directly on the data, because it was an .xml file. Actually, in my first piece I did a lot of stuff like writing .xml files on a text editor. If you are a SuperCollider user, you could also write software in SuperCollider and generate paths.

AA: In a certain way I guess it is interesting to think about what is important in this kind of music. I mean, what is first: the chicken or the egg? Translated to music, what is first: space or sound?

AS: Well, there is a third factor and that is technology.

AA: Is that factor a sort of liberation for space? Does this machine contribute somehow to it?

AS: I think if you look at the French guys², they were starting with radio, tape recorders, recorded sound and they were thinking about manipulating recording sounds. So, that is why they built equipment like tape recorders that could change pitch without changing the duration and stuff like that. Actually, Stockhausen did his first electronic piece there as well. He was more into ideas like completely dissecting everything into molecular units and constructing from that as the total super-genius. That led to his electronic pieces using sine generators, which were available at that time. The Italian example, the Studio di Fonologia, really started from language, because Umberto Eco was also involved in that studio and Berio was married to the singer Cathy Berberian. So, they were more language-oriented. Their idea of working with filters indeed comes from the research on the human voice. The voice works like a generator somewhere over here [*points to his throat*] and a filter somewhere over here [*points to his mouth*]. That was their idea of using equipment.

My thinking about space started to evolve reflecting about what moving a source means, because if you think about sound, sound always starts with movement. I clap my hands and... bang! We have sound. We made it by moving two hands. In general, sound is always about two things touching each other. If you blow a flute, it is the air is touching some small mouthpiece. It is easy to imagine how percussion works. If I hit this or hit that with my knuckle [*knocking the table with his hand*], the sound is different, because the knuckle could be the same, but the other thing I am touching is made of a different material. If movement causes sound, you can think about sources that do not move themselves, but they are touched by movement in order to create sound. It is the movement that touches that is moving, and the thing that is touched that remains in place. The result is that you do not hear a sound source moving, but instead you hear a touching force moving through space. This is something I am thinking about now and this is something that can only be done with a WFS system, because you are able to place sound in space. You can compare it with the sound of trees. If you are in the country and hear the wind, sometimes you hear it coming from really far. It is the wind touching the leaves, which are like small granular particles. You can hear the wind moving. You can even hear the direction the wind is moving in because of the subsequent trees it is touching. This is something I am researching now: in order to make sound, you have static sources together with moving forces.

² Groupe de Recherches Musicales [INA/GRM] at Radio France, Paris.

AA: *There is even more space sense here, from your point of view; that is most closely related to the physical idea of sound. Maybe that is the part of music that is not really observed: that sound is alive and it is alive because it moves. WFS contributes much more, for instance to express sounds selves in a non-perceptual way, because there is physical principles behind [below] it, but at the same time you have an idea of sound as a moving source. It is the Xenakis idea as well of moving sounds. It is not an object. I guess you could sculpt sound, you could observe some minor things surrounding it... No, it is sound what moves.*

AS: Of course, it is close to Xenakis' thinking.

AA: *But not in that way...*

AS: It is different, because Xenakis' thinking is closely connected to orchestral instrumental music. His electronic music is really a small part of his oeuvre. What he did in orchestral music, interesting indeed, is seeing all these instruments generating small particles of sound together forming a mass of sound.

AA: *Even the same adopting patterns and behavioral reactions: what to do from the first violin #1 until the first violin #16. Or what is the route around this section of music stands.*

AS: He is not using 16 violins as a group of violins, but 16 individual sound sources.

AA: *But in the polytopes installations, as for instance Persepolis, sound is only one of the things that is related completely to movement, besides light designing, installation and so on, in which generally are millions of instructions designed for that. I have the impression that in the way you describe, it reminds a lot to me to the Persepolis idea of some people porting candles or lights, then doing a procession moving everywhere, creating a bigger space. In more abstract terms, The WFS is more like this, is not it?*

AS: What I find with Xenakis's music and his idea of particles is that it started with his war experiences, where there are large masses of people, shouting... It is like a pop concert: you really hear those waves of shouting, all these particles of sounds. This is a starting image for wanting to do these kinds of things. But with Xenakis it always stays on the sound level. If you really look at the movement of sound in the polytope, it is really minimal, I mean, it is not about moving sources. He was not so much interested in that kind of movement, but more in movement inside sound. What I find interesting now is a more physically experienced musical thinking about space. Like the example I mentioned before, if I stand in the country, every different position has a different perspective of the event, but no perspective is better than the other. So, I am thinking about music more as an ambience, and not like something that is fixed in a score and can be presented as such, but more like an environment that has many perspectives.

The thing is that this kind of thinking related to space started working with the WFS system and thinking about the implications. In the end it is the technology giving you the possibilities. It happens often that a piece of technology was invented for A, but being used for B, because someone found out that it was really nice to do this other thing, which it was not invented for. To think through the WFS system is to lead oneself to new ways of making music. In my next project, I will try to integrate some things that I did in my first piece, moving sources as personalities that have a certain ways of moving. Like bees or drunkards...

AA: *What is the infinite and what is the boundary in this system for you? What are the endless possibilities and what the limitations?*

AS: The infinite possibilities come from your imagination; I hope it will be infinite, at least for the time I am alive! [laughs]. The current limitation of the system is the third dimension. I think that, in order to go really further into this ambient thing, it would probably help to have a 3D surround system. It would not change your thinking, but you could play with height. That is not really possible at the moment.

AA: *Probably you would not need too much speakers at the top or at the bottom.*

AS: According to the theory, hanging one array on the ceiling would be enough to recreate acoustics that people cannot easily discern from the real thing.

AA: *For instance, in the ark for Prometeo, a project by the composer Luigi Nono and the architect Renzo Piano, there were some electronic stuff and so on. But there were an idea not so close to the idea of Osaka Pavilion Stockhausen's installation, but something related to, though.*

AS: I think it is different to Stockhausen's installation; I think that Nono's piece was more about ambience than any of Xenakis' or Stockhausen's pieces ever. If you look at the picture of the structure, you see this ark. There is scaffolding all around the walls and the musicians are really scattered over the whole structure. If you listen to the piece, you have soft sounds coming from somewhere. If you image the performance in that space [pointing imaginarily with the finger] and the sound comes from there [pointing to other direction], then it is like ambient music.

AA: *But there were a sort of evolution in those days; there was the 1980's. But what was about some years before, for instance the Philips Pavilion in 1958? The introduction of a respectable amount of speakers; there were routes implemented by mechanical means. We had some time ago the opportunity to listen to Concrete PH in a Game of Life Foundation WFS concert at Scheltema Complex – Leiden organized together with the Institute of Sonology, in which were used probably the original routes designed in those days, which were written down in some notes by Xenakis. Originally they were not applied on the basis of physics.*

AS: But the Varèse's Philips system is also different. I heard a recreation of this system somewhere in the 1980's by ASKO Ensemble. The reason why this system worked out is because it was actually a mono system with many speakers.

AA: *So, it is about location.*

AS: You can localize the sound really precise because it comes from where the speaker is. The nice thing is that they had to build this crazy equipment to move the sound over the speakers; it moves like a roller coaster. I heard *Poème électronique* over a reconstruction of this system and it sounds completely different from any stereo recording. The sound moving over this speaker system really sounds like sounds moving in a roller coaster.

AA: *It somehow comparable occurs with the musique concrète first compositions by the GRM. Daniel Teruggi told me that, especially at the beginnings, some people only brought one mono file. And then, this mono file was the whole raw material, especially with the first pieces of*

Pierre Schaeffer, like for example Etude aux Chemins de Fer. These pieces are mono, but the interesting thing is was how to recreate that space for them. And probably this is the point: although at the beginning you had a set of speakers, and it implies certain implicit idea on space, however the idea was not to play farer away than physics: that was a perceptual play.

AS: The Philips Pavilion was an installation; it was made for *Poème électronique* and if you wanted to do a piece on that system, the routes were predefined, because you could not move the speaker installation. It would imply to make a new building. It was made for only one composition through one speaker system. Nono's *Prometeo* is like an ambient composition. What Stockhausen did in Osaka was to invent a really incredible multi-channel system, but he did not use it. He built a special joystick, so he could move sources by hand. Sounds were sent to eleven speaker groups with the movement of the joystick.

AA: What kind of relationship do you find between the spaces you visit and the system. Not every space behaves appropriately with the WFS, but probably in several occasions is the other way around. You often find surprises because the acoustics, and so on and so forth. How do you deal with this controversy between the implicit spaces invented through the WFS system and the visited spaces? In the case of Nono/Piano's Prometeo, the project ship-like traveled to different places: a church in Venice, a factory in Milan too. This system contributes also to create the magic and disappear: you go to one place to create something and there is an interaction with the space. What are your perceptual remarks on it?

AS: There is an interaction with space, but as you say, working with speaker systems is always a piling up of many spaces. You can easily discern like seven spaces you are piling up. About WFS, I recently had a discussion in Spain with someone who said that the system could only work in an anechoic room. I said to him I would not be so sure [with irony]. The physics in an anechoic room are not different from that in any other room: only the acoustics change. Additionally, you would not hear just the system in an anechoic room. If you have been into an anechoic room, you can hear your blood pumping in your ears: it is not nice. And you can hear a high pitch of your nervous system. If you would have complete silence in your composition, you would immediately start introducing noise to cover up the sounds that come from your own body. If you really compose for that anechoic room, you would adapt your piece to the space.

The building in which the system is set nowadays is made of concrete and used to be a parking-garage. This space has a certain acoustics. Of course, you can go to places where the ambience is has a longer reverberation time. You can have an over-reverberant church where everything swims and washes. I would be really hard to listen to some pieces, though not impossible. On the other hand, you can have spaces that are acoustically really well treated and then the system sounds amazing. My general experience is that the larger the hall, the better it works. It would include factory halls and these kinds of spaces, because you have walls that are not very close. So if there were any earlier reflections, they would be really late.

AA: Therefore, the real limitation is the physical limitation. For instance, if you go to a large church, you would start to feel the space because the space sounds, not because the system, would not you?

AS: Maybe this is another layer we should think more about. On the other hand one should not worry too much about spaces. From a technical point of view, maybe we could think about making some kind of adaptation for really dry acoustics. On the other hand you can compose for specific spaces... but then the mobile part of the system would be gone. So, you would make an installation again. In the end the WFS system is a nice toy, but not the toy to end all other kinds of speaker systems.

AA: Do you think then that 'Toys R Us'?

AS: [Laughing] Every technical artifact is a kind of toy you can play with. So WFS offers to you certain possibilities. It gives you some problems as well in the sense of sound projection, timing, and so on. Playing with speakers is really something of an exploration, in an intellectual philosophical sense as well as in a musical sense.