# Acoustic Modelling as a Strategy for Composing Site-Specific Music

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## ABSTRACT

This paper describes two site-specific musical compositions, focusing on how modelling was used in their respective composition processes. Primarily, the acoustics of the sites were modelled to aid in the preparation and composition of the pieces. From this we propose the general use of modelling as a way to work with the concept of site. But the idea of formulating a model is also applicable more widely in the work described and this is discussed with the two pieces as starting points.

Both pieces use acoustic room scale feedback as their only source of sound, so the impact of the room, speakers and microphones used is immense. The first piece, *Rundgång*, is a commission for the *GRM Acousmonium*. The second piece, *Clockwork*, is a public installation that will also be the site of a performance, combining the installation with live interventions. Clockwork will also employ modelling as a component of the piece itself, and include a remote performer and a remote audience. We suggest that there are possibilities to employ compositional strategies to embrace these kinds of hybrid presence situations by composing for many vantage points.

## CCS CONCEPTS

• **Applied computing** → **Performing arts**; *Media arts.*

## KEYWORDS

modelling, composition, electroacoustic music, site specificity, presence, feedback, acoustics, room impulse response

**ACM Reference Format:**
Ludvig Elblaus and Gerhard Eckel. 2020. Acoustic Modelling as a Strategy for Composing Site-Specific Music. In *Proceedings of the 15th International Audio Mostly Conference (AM'20), September 15–17, 2020, Graz, Austria.* ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3411109.3411141

## 1 INTRODUCTION

In this paper, we describe how we have worked with modelled room acoustics to successfully engage with both practical and artistic problems. This is illustrated using two case studies, two compositional processes, that serve as examples of how this approach can be employed in ideation, composition, rehearsals, performance, and installation work. While the first piece has been performed, the premiere of the second piece is six months ahead in time at the time of this writing, so this paper will focus on the composition processes.

The importance of room acoustics, both physical and digital, is heightened by the fact that our musical work is made up entirely of acoustic feedback in an interplay between digital processing software, electroacoustic transducers, and the rooms the performances take place in. Therefore, modelled room acoustics are not just an added flavour that, while important, still constitutes something external to the musical material that makes up the piece, a circumstance or context. On the contrary, it gives insights into the fundamental building blocks defining what will be possible to achieve musically.

Because of its tight coupling with the spaces it inhabits, the work presented in this paper is naturally concerned with presence and integration of piece and place. This kind of artistic approach is sometimes referred to as site-specific work. Here, *site* can be understood to be the sum of all the materials, behaviours, circumstances and contexts provided for the piece by its environment. As the most important site-specific characteristic in our work is the interplay between the room acoustics, the loudspeakers, and microphones in the space, this is the materiality that will be used as an example for this paper. We will show how we work with acoustics conceptually and technically, with artistic concerns and goals.

As stated above, two pieces will be presented. The first one, *Rundgång*, is an electroacoustic piece commissioned for the *Groupe de Recherches Musicales* (GRM) *Acousmonium*, premiered in 2020. The second one, *Clockwork*, is an installation that at one point will host a concert performance. It is to be installed as a permanent installation in the fall of 2020, and the concert will function as the inauguration of the installation. Both pieces make use of impulse response measurements and real-time convolution to explore physical acoustics through modelling it. How this practice can function, both artistically and technically, is the main topic of this paper.

We have developed a tool for capturing room acoustic features through impulse responses allowing us to model physical spaces. The design of this tool is grounded in our artistic practice, but describing it in detail is beyond the scope of this paper. Instead, we refer to *utruchirp - An Impulse Response Measurement and Auralisation Tool Developed for Artistic Practice* [9]. We have also developed an elaborate framework that allows us to create and manipulate feedback networks of high complexity. This piece of software, called *utruchord*, will also be described thoroughly in a separate forthcoming publication.


*AM'20, September 15–17, 2020, Graz, Austria*

ACM ISBN 978-1-4503-7563-4/20/09…$15.00
https://doi.org/10.1145/3411109.3411141

In this paper however, we want to focus on how the tools and techniques function in the processes and pieces described herein, leaving the technical details for the other publications.

While our practice of remote work via modelling of physical spaces has been developing for quite some time, the current situation and indeed the online characteristics of the present Audio Mostly conference itself further actualises the topic. As we will show in the presentations of the pieces, our initial motivation to explore these techniques were practical concerns, e.g. to provide access to venues without visiting them physically, to reduce travel or because access was otherwise limited. These restrictions are currently in exceptional effect. Going forward, other motivations, e.g. environmental impact, might motivate us as a community to restrict ourselves in a similar fashion. Whatever future we face, we hope the material explored in this work will provide useful for our field going forward.

### 1.1 utrumque

The work presented in this paper stems from a collaborative research platform, created by Eckel and Elblaus, titled *utrumque*[1]. utrumque has been active since the start of 2019. Setting out to explore audio installations, the project has produced several workshops, pieces, performances and fixed media publications. The artistic concerns of the utrumque project are very much entangled with the notions of space, place, experience and qualities of presence. The main material used in these explorations are dynamical systems involving acoustic feedback. This approach, to excite the space the audience is in, and thereby turning it into the resonant chamber of a room scale acoustic instrument, provides a rich and particular experience with many interesting qualities. One such quality is that people attending the same event are in fact not only experiencing a highly individual perspectives of the piece, but are also affecting the experience everyone else is having. Not only from a constructivist aesthetics point of view, where the experience of art is co-produced by its audience, but also because of acoustics, be it room acoustics, instrument acoustics, or psychoacoustics.

Since the fundamental musical gesture for utrumque is the activation of a space using acoustic feedback, questions of physicality and presence are intrinsic to all of the work. The characteristics of the built environment and how those acoustic properties lay the ground for what is possible in a space is of course central, but just as important is how one's own physical presence in the space modulates those characteristics. Like in the dizzying realm of quantum mechanics, the observation changes that which is observed. There is no such thing as a passive listener since our bodies immediately dispel that notion by absorbing and scattering sound [4]. Furthermore, the acoustic activation of a space transcends the idea of a *sweet spot*, i.e. a preferred or even correct listening position. Instead, everyone present will be uniquely situated in a personal acoustic vantage point. Sometimes the differences are subtle, sometimes immense, but the audience are all the time aware of the physical reality of their bodily presence.

The work of utrumque is site specific, but the site is as much an emergent dynamic combination of its inhabitants as a static sum of its surfaces and voids. The work is to be enjoyed by an audience, but it is also hyper localised, and audience members might get served very different sounds as a result of their position or the way they explore the space. It goes beyond using a site as framing, it exposes how our physical presence in a space is a fundamental component of musical experience.

[1] https://utrumque.com

### 1.2 On models and simulations

The work presented in this paper relies heavily on techniques for measuring a room and a set of transducers in that room, i.e. loudspeakers and microphones. Those measurements are processed and used in digital signal processing software to model some of the qualities of the measured room acoustics and transducers. This is not in itself a new concept and it is in wide use. The full technical details of convolution and its applications are beyond the scope of this text. For a good overview of the swept-sine technique used we refer to Farina [10, 11], and for a more technical look on our own practice, we again refer to our paper on utruchirp [9]. However, the particular use cases described in this paper are novel and by detailing our approach, we hope that this way of working can be more widely adopted. But before we delve into those details, some clarifications of how a few key terms will be used in this text are needed.

When a *measurement* of a room is made, an excitation signal is played into the space and the resulting reverberated signal is captured. The captured signal is then processed to produce an impulse response that when used in a certain software can be used as a *model* that can serve to *simulate* the room that was measured. It should be clear that it is only a very small number of characteristics of the room that are indeed captured, out of all the possible ways to measure our physical world. Still, the measurement enables a model of the room that carries with it *significantly many useful qualities* of the measured room. Such models are of a high enough fidelity in those respects relevant for our practice that we can use them as simulations.

Therefore, when we use the term *simulation* in the text, it should be clear to the reader that we mean a specific type of model that is used to simulate a small but useful subset of the qualities of a room at the time of measurement.

## 2 RELATED WORK

Art that relates to place in an explicit way, often in combination with having a permanently fixed locale, can be seen as *site specific*. Crimp writes about how one of Richard Serra's pieces fused with its site that "[t]he work was conceived for the site, built on the site, had become an integral part of the site, altered the very nature of the site. Remove it and the work would simply cease to exist" [5]. Irwin distinguishes four categories, *site dominant*, *site adjusted*, *site specific*, and *site conditioned/determined* [14], and the work presented in this paper would arguably fit into the latter two categories. Kwon frames the idea of the site-specific in a globalised world where "[...] the success and validity of one's work are now measured in the accumulation of frequent flyer miles", and notes that it "seems historically inevitable that we leave behind the nostalgic notion of a site and identity as essentially bound to the physical actualities of a place" [15]. However, music, compared to much of the broader field of contemporary art, is particular in its relationship to space.

Hayes writes, it "seems obvious to point out, then, that musicians are constantly responding to the spaces and situations in which they perform", but identifies a difference in electronic music in that it lacks a standardised performance environment, writing that "live electronic Western art music has no architectural home", preferring the term *site responsive* to describe how to relate to the largely heterogeneous spaces electronic music is performed in [13].

The intricacy of the relationship between sound and space, between music and acoustics, is hard to overstate. It can even be argued that any musical act is primarily an interference with an already present acoustic situation, as Alvim writes, "[t]he composer, much like the architect, plans a particular modulation of space used, thus their main production is not an object of contemplation, but a situation in space." [1]. The concept of *In Situ Composition* realises that notion quite literally, by placing the composer and indeed the compositional process, in situ, on site [7]. Krogh Groth and Samson also reframe the duality of work and site by using the term *sound art situation* to, among other things, be able to include audience participation and other wider social aspects [12]. It might indeed be the case that employing site-specific strategies without considering the situation carefully may lead to problematic results, as "musicians, composers and sound artists [are lacking] formal training in dealing with real-world issues, as well as acoustics" [19].

The relationship between music and site has been further complicated by the possibility of remote presence, both by performers and audience. The idea of networked music has been around for at least a couple of decades, depending on how one defines it. A good overview tracing the origins and early development can be found in Renaud et al. [17]. The primary technical bottleneck in all remote or networked music performance is latency [2]. Olivieros writes on one of the reasons for creating networked music is because we can, and goes on to say that "JackTrip has practically eliminated significant latency for audio." [16]. While this might be true in a technical sense, in practice, latency and consequently synchronicity and experienced immediacy is not a solved problem. This becomes even more prevalent if a larger number of audio streams are combined with one or more video streams. Chafe et al. have shown that latency can affect ensemble play, causing it to either speed up or slow down [3].

The use of acoustic feedback as musical material has been wide spread for some time, for a good historical introduction, see *Between Air and Electricity* by Cathy van Eck [20]. Sanfilippo and Valle draw up an excellent systematisation [18], arriving at five main features one can use to classify feedback systems. It should be noted that here, feedback system includes systems beyond analogue feedback, i.e. microphones connected to speakers, such as purely digital constructions, or systems that listen to their environment and analyse it for information that is used to decide what signals are produced. An example of the latter is Di Scipio's *Audible Eco-Systemic Interface* [6].

## 3 ARTISTIC EXEMPLARS

In this section, we will describe two pieces with the intent of showing how the room modelling techniques described in the introduction can be applied to artistic practice, both to solve practical problems and help with resource management and logistical concerns, but also how they become essential for artistic exploration of sound synthesis, composition, site and presence.

### 3.1 Rundgång

Rundgång is a 20 minute electroacoustic piece commissioned for the GRM Acousmonium. It was premiered in the *Ligeti Hall* in *MUMUTH*, Graz, during the *Elevate Festival*[2], in 2020. The Acousmonium is a loudspeaker orchestra, created by Francois Bayle in 1974, then the head of GRM. It consists of a large and heterogeneous collection of speakers placed mainly in front of and also around an audience in a concert setting.

The central idea of the Acousmonium is to diffuse fixed media pieces by playing a mixing desk that distributes the incoming sound, from a stereo reel-to-reel tape machine for instance, to the speakers. By exploiting the different characteristics and positions of the speakers, tonal and spatial expression is possible. In this sense, the Acousmonium differs from evenly spaced and homogeneous multi-channel setups popular today, where rings or domes of identical speakers are setup to provide a neutral and transparent playback experience. On the contrary, the Acousmonium and other loudspeaker orchestras like it are made to offer a varied palette of colouring, with the intention of creating a unique and singular playback experience.

The practice of playing the Acousmonium relies on a combination of knowledge about the Acousmonium itself, the piece one is performing, the space one is performing in, as well as the not inconsequential degree of dexterity needed to manipulate the large number of faders on the console. A piece can be played in any number of ways, and it takes a skilled performer to be able to make use of the richness and nuances of the loudspeaker orchestra.

Because of the particular technical setup, preparing a piece relying on acoustic feedback for the Acousmonium posed several practical challenges. Primarily, it would be costly and impractical to create even a remotely similar setup for rehearsals and composition because of the size, variety, and uniqueness of the equipment that the Acousmonium is composed of. Yet, the singular characteristics of the Acousmonium were sure to have a big impact on the music in our case. As contrasting comparison, approximating a stereo PA on a stage with a stereo setup in a studio is both more accurate, as it is less of a leap, and also more readily available.

We decided to approach the compositional process using two methods: First, to augment our studio environments by using a chamber music hall to compose in, in order to get a better sense of how our material interacted with a larger space. Second, to create approximations of the Acousmonium by simulating different loudspeaker setups with room models that were assemblages of several existing measurements of the Ligeti Hall.

The initial conceptual seed of the piece was to try to use a single microphone that, through our digital signal processing, would produce separate layers, each yielding a single mono channel, that could be individually panned to any speaker on the Acousmonium, to focus on the intricate interplay of the many different kinds of

[2]A recording of that performance can be streamed at https://soundcloud.com/utrumque/rundgang.

**Figure 1: The performance of Rundgång on the Acousmonium in the Ligeti Hall in MUMUTH. The microphone can be seen in the centre of the picture, ©Clara Wildberger.**

loudspeakers and their placement in the room. This would highlight the qualities of the Acousmonium with a precision that would complement the repertoire of more maximalist multi-channel spatialisations. The two stage approach of using a physical and a digital model of the performance situation was designed to allow us to validate the compositional decisions throughout the process using experiential immersion.

*3.1.1 Initial Material Generation.* While the Ligeti hall in MUMUTH, where the piece was to be premiered, has a long reverberation time, we decided to do our initial material generation in an acoustic situation with a shorter reverberation time but a more lively acoustic in the sense of the balance between the direct sound and its reverberation. We overshot the target acoustics with the intent of overemphasising the contribution of the room in terms of diffusion and relative level of the reverb. We used a chamber music hall, the *Milstein Hall* at The Royal College of Music in Stockholm, which is about a third of the size of the Ligeti Hall but with warm and lively acoustics. Interestingly, this led us to produce material with a certain quality, a spatial richness of an almost vibrating character, that only presented itself when the material was generated in a physical space. If the same digital processing was connected to simulated acoustics the qualities were not present, even if the simulated acoustics was created using a measurement of the very same setup in the hall.

However, having heard the material in a richly reverberant physical space, we could imagine this quality in the later listening in simulated acoustic environments. This was fundamental to the construction of the piece, as it confirmed our hypothesis that a subtle and rich spatialisation was possible using a single mono feedback channel, without the perceived sound stage collapsing into a single directional sound source localised at a speaker. If we would have started in the digital simulated acoustics, any such qualities would have remained hidden and only emerged as a surprise when moving into a larger physical space for the first time.

*3.1.2 Modelling the Acousmonium.* In order to approximate the interaction of an Acousmonium setup with the acoustics of the Ligeti hall, existing room impulse measurements from the hall were used to create a simulation. The measurements were realised in the context of the artistic research project "The Choreography of Sound" (CoS), which was concerned with exploring non-standard ways of sound spatialisation [8]. The CoS database, completed in 2010 and published with the *StiffNeck* tool [7], contains measurements for 47.268 loudspeaker and microphone pairs, representing a large set of speaker configurations for various listening positions and orientations. From these, an imaginary and scaled-down Acousmonium setup including only 16 virtual speakers was constructed. The virtual Acousmonium speakers could be rendered for a centrally placed dummy head producing a binaural signal to listen to and for two omni-directional microphones, providing two options for feedback channels.

*3.1.3 The piece.* The final version of Rundgång was arrived at through a series of iterations of refinements and test performances in simulated acoustics. The signal flow in the piece is simple: a microphone connects to a computer via an audio device, the computer processes the sound using the utruchord software, the sound is played on the Acousmonium speakers. Looking more closely at the software part, there are three layers of separate parallel signal processing chains that all take the microphone as their input and generate a mono output that is panned somewhere on the Acousmonium's many speakers. This means that in the resulting feedback, all sound is summed into one mono channel at the microphone. Each layer in the software contains a filter bank with a fixed number of bands (16, 8, and 32), filter slope (96, 48, and 96 dB per octave respectively), and varying transition frequencies and overlap throughout the piece.

The piece starts and stops with a staged intervention where a person steps into a spotlight on stage where a microphone is placed on a stand and completes the feedback loop by connecting the cable to the microphone. At the premiere, choreographer and dancer Alexander Gottfarb composed and performed this part. When the mic is plugged in, the piece is already playing through a score that animates some of the parameters in the software by interpolating

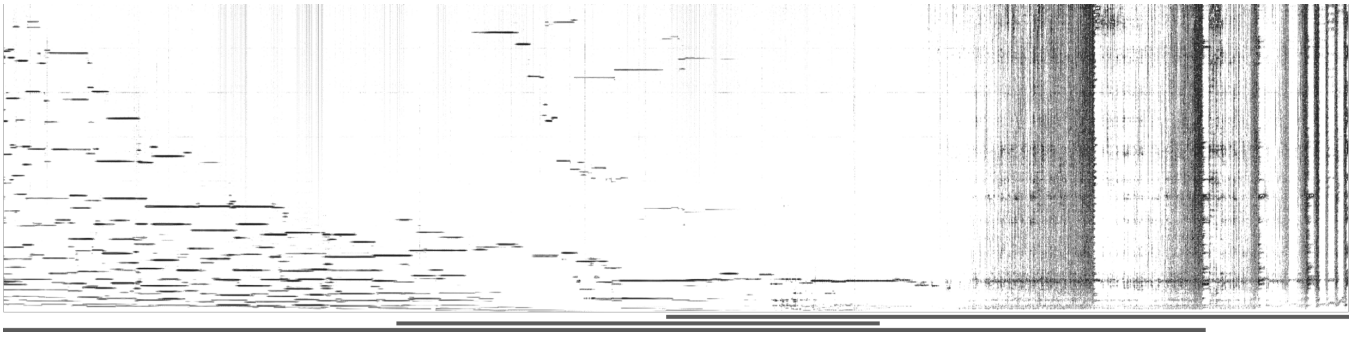

**Figure 2: A spectrogram of Rundgång combined with indications of when the three layers are active, but not neccessarily heard, due to long fades in and out. Note that it is only in a very short transition period of 3 minutes where all three layer play at once, and that for most parts of the the piece, only a single monophonic feedback loop is heard.**

between values placed on a timeline. The first layer moves slowly around the room using the outermost speakers, the second uses a set of speakers on stage and uses a higher register than the first, the third complements the smooth panning movement of the first two by jumping between speakers at an increasing rate, starting with six speakers in the middle and using speakers all over the hall towards the end of the piece. After a set number of repetitions of the jumping gesture, the microphone is unplugged, abruptly ending the piece that could otherwise have gone one indefinitely. The overarching form of the piece and the ways the three layers overlapped over time can be seen in Figure 2.

*3.1.4 On-site tuning and performance.* Even with all the preparations described above, setting up the piece on the actual Acousmonium required a lot of on-site tuning. We will focus on two main challenges, gain staging and the discrepancy between inserting a signal into a digital simulation and sending an electrical signal to a loudspeaker.

First, having the console inserted in the feedback path added complexity to the gain staging, as there was now a shift in the unity gain, there were individual level controls for each speaker, as well as a master level. For the performance, the levels of the individual speakers and master level and the equalization of the microphone signal were played live to compensate for the altered acoustics of the performance environment, i.e. having the audience in the room changed the acoustics substantially, thus causing the piece to play quite differently.

The second big difference came from the discontinuities caused by the jumping of the third layer. Because of the linearity of the digital models used for room simulation, injecting a step function, similar to what happens if you have a continuous sound played in one loudspeaker that within the space of one digital sample is moved to another loudspeaker, results in the perfect reproduction and subsequent reverberation of that step function. This is not the case with physical speaker cones. Therefore, simulating the effect of these discontinuities was impossible and highlights the need for adding nonlinearities to the simulations. This required not only careful tuning of the static gain controls, but also a long rehearsal process where a strategy for riding the master level to a quite dramatic degree in the last quarter of the piece was devised and practised.

## 3.2 Clockwork

While Rundgång is a good example of how simulation and modelling can be used, both practically and artistically, the process and the piece itself are still straight forward and easy to follow. The second piece, Clockwork, explores a more complicated situation. Clockwork uses two physical spaces, the CUBE concert space and a staircase situated in the same building at IEM in Graz. The two are connected through a corridor and one can go from one to the other in less then a minute, but because of the length of the corridor and its several doors, the two spaces are acoustically disconnected. The two spaces can be seen in Figure 3.

In the piece, the two spaces are set up so that microphones in one can be played through loudspeakers in the other and vice versa. Furthermore, the spaces can be fed back into themselves, and all inputs and outputs are run through our custom signal processing software, utruchord. The utruchord software manages the selection and distribution of the connections, and the two physical rooms are simply connected via two cables providing a mono signal in each direction.

The piece creates pseudo-periodic musical gestures by panning a feedback loop in the CUBE depending on the amplitude of the signal produced by that very same loop. This works as a self limiting system since when the signal gets louder, it gets moved to a new position in the room, thus changing the phase relationship between the speaker and microphone membranes. In the feedback loop there is a filter bank with individual dynamical compression per band that makes it possible to create even further variation in what kind of patterns emerge from the amplitude controlled panning. The dynamical system in the CUBE is also fed the sounds from the staircase. Simultaneously, the sounds from the CUBE are also played in the staircase, making the resulting system highly complex and capable of great variation, while simultaneously being a result of the acoustic properties of the two spaces.

Clockwork will appear in three forms: as a permanent installation, a temporary installation, and a concert performed in the installation. The permanent form is meant to replace the current

**Figure 3: From left to right, the figure shows: The staircase vertically; The staircase and how it opens up to each floor; The CUBE concert hall.**

installation *Staircase*[3] which is sounding the building since 2008. The permanent installation is meant to blend into the everyday sonic and architectural situation of the staircase as much as its predecessor did, in order to be embraced by the people frequenting the building, typically university students and staff. The temporary form will be exhibited during the hours surrounding the concert performance. The temporary form of the installation will exhibit a more lively attitude with respect to the sonic and social situation in the building, offering a more concert like experience. The concert will function as an inauguration of the permanent installation and use the more lively temporary installation as an actively co-creative performance environment into which interfering sounds can be interjected.

All three forms connect two spaces in the same building, the staircase and the concert hall. In fact, in order to get to the concert hall, the audience will pass through the staircase, where they will encounter the piece first in its installation form. Both spaces are permanently equipped with loudspeakers and microphones since more than 10 years. The staircase has 1 microphone and 2 speakers and the concert hall 7 microphones and 24 speakers. The piece makes maximum use of this existing infrastructure. In the concert, both spaces will be accessible for the local audience, whereas in the other two forms, a model of the concert hall will be used instead of the actual space, as the latter is needed for other purposes as well - it's also a lab space, a lecture hall, a recording studio, a rehearsal and performance space, etc.

There are two levels of remoteness involved in the piece and its forms. The two spaces are remote to each other and being in one of them makes the other one only possible to be experienced remotely, even though they are mutually connected, acoustically entangled. The concert in the installation will be streamed over the Internet, and because of the current situation, most of the audience will experience the piece remotely.

Whereas the local audience has the possibility to move from one space to the other, between the concert hall and the staircase, through the 35 meter long corridor, the remote audience will be given the option to switch between streams from the two spaces, allowing for an certain amount of spatial engagement with the piece. A similar option can be imagined for the documentation of all three forms, allowing a change of the listening perspective, maybe enabling to adopt several listening angles in each space, which is made possible through the techniques of acoustical modelling employed.

From the composer and performer perspective, Clockwork contains several different but connected stages, as well as many different kinds of presence for both audience and performers to relate to the piece. In a brief summary, the stages of composition and performance are:

(1) All preparatory work and composition will take place in simulations of the two spaces.
(2) The on-site tuning will be done in the physical spaces, in person by one of the authors and remotely by the other author.
(3) As stated above, the two spaces will be open for some duration as a temporary installation, with audience members having access to both rooms. The installation will also be open for remote audiences.
(4) The concert will be performed in the temporary installation by both authors, one physically present and the other remotely present, still with audiences in both physical spaces and connected remotely.
(5) After the concert, a permanent installation version of the piece will remain in the staircase, now instead connected to a simulation of the CUBE. A recording of the concert, as experienced in the CUBE will be produced. A record of the remote experience of the installation and concert will also be produced, allowing also that experience to be repeated.

The compositional approach used in the creation of Clockwork relies heavily on room modelling and would indeed be impossible without it. It is important to note, that in comparison to Rundgång, in Clockwork, the modelling goes beyond solving practical problems by simulation and the use of an ersatz room. Instead, the models enable a playful perspective on presence in a much broader sense. This is further developed by the fact that a majority of the audience and indeed one of the performers are physically absent from the concert space. In the final permanent installation, even the room where most of the sounds in the piece are produced is quiet, seemingly removed from the equation physically but never the less still sonically present.

While Clockwork employs a complex strategy regarding ideas of place and presence in space, it also engages with how the passage

[3] http://iem.at/staircase/staircase.html

of time is modelled, thus playing with both space and time. Central to the piece is a calendar model, a piece of computer software that computes phase values, a normalised position between zero and one, for different time periods. This inner model is also the reason for the title of the piece.

The time periods are those commonly found in everyday models of time keeping, e.g. seconds, minutes, hours, days, but also other divisions, like seasons and semesters. These phase values, e.g. noon being a value of 0.5 for the day phase, are then remapped onto parameters in the digital signal processing part of the piece. Some periods are quite short compared to others, e.g. a minute and a year. Some periods sync up, e.g. the minute and the year, while some do not, like the week and the month. This inner mechanic makes Clockwork share a pattern of import with the regular calendar, for instance the stroke of midnight on new years eve will be an important event also in the piece, as many phases will jump from one to zero. In the concert version of Clockwork, the calendar will be disconnected from the actual clock, and we will be free to move around in any speed and any direction, making years seem like minutes or seconds like seasons.

# 4 DISCUSSION

## 4.1 Site specificity

The work presented in this paper is site-specific already in its inception, the conceptual stance straddles Irwin's two categories of site conditioned and site-specific art. Furthermore, as a consequence of the use of room scale acoustic feedback, the fundamental material from which both pieces discussed in this paper are composed, is in a very real sense the result of the combination of our tools and intentions and the sites themselves. Without a site, there is no piece. In fact, the way the system of sound production is setup, without a site, there isn't even sound, as the removal of the resonating chamber breaks the feedback loop, rendering the process silent. As such, we must consider our work to be interventions or interferences in pre-existing acoustic spaces. The agency to interfere is not unidirectional. Different spaces affords different musical gestures and are conducive to different compositional structures, that in turn leads us to reshape and adapt our tools to better align what we can do with what the space can do. Our main tool, utruchord, with which we create our instruments and pieces, therefore carries with it sediments of practically all spaces we have performed in. In a way, not only the pieces emerge in the meeting with the site, but also the development of our software is to some degree co-authored with the spaces we engage with.

Site specificity can therefore be understood as something much more than an immanent quality of the pieces, instead, it is an intentionality that is present in all aspects of the compositional process. Any and all characteristics and qualities of an imagined performance can be used to inform the creation of the piece. This attitude can perhaps be even more clearly seen in its negation. Consider the traditional theatre black box, or the symmetric standardised loudspeaker setups of the electroacoustic concert halls. Here, the explicit and purposeful erasing of the identity of the physical space, in favour of virtual spatialised staging, is carried out to ensure the seamless transferability of individual pieces. This infrastructure, theoretically ensuring that any piece can be projected in any place, is a fundamental necessity for the contemporary music circuit. In this admittedly sharply drawn comparison, the original function of site-specific art as a critique of the modernist white cube and its surrounding economic infrastructure is an interesting juxtaposition. As our contemporary situation is once again concerned with site, as in the divide of being on site or remote, positions of physical absence and mediated presence, artistic investigations of experiential qualities in connecting sensually to a particular place has never been more needed.

Let us therefore open up the question: What different kinds of presence are available in Clockwork and how do they function? Can we understand them as only differing in fidelity, adopting the understanding that there exists an objectively correct experience of the piece, that becomes more and more diluted the more peripheral the vantage point of the observer? Or can we instead understand them as different but equally valid? We propose the latter. Our general approach to audience experience, because of how the nature of our musical material carries with it a built-in reversal of the *sweet spot* idea prevalent in electroacoustic music, motivates us to embrace the variety of vantage points. Therefore, we find it more generative to take the position that there is no dichotomy between presence and absence, nor a sliding scale between the two endpoints. Instead, there exists a much more complex multidimensional weave of vantage points. Dealing with this then becomes a compositional challenge, an artistic endeavour that surely relies on technical innovation, but an artistic challenge nonetheless. Assuming the understanding that the site contains a multitude of vantage points, compositional practice must relate to that in an explicit way. Our work on Rundgång and Clockwork takes on several of these questions and the insights from those processes point to some suggestions:

*4.1.1 Compose for many vantage points.* Exploit their strengths and variety to create as meaningful experiences as possible. This is a continuation of our practice of relating to multitudes of unique experiential vantage points in the shared physical acoustic space. In Rundgång, we could only understand the experience of a particular audience member in a statistical way, because of how the standing waves present themselves spatially in the hall, e.g. when the sound was loud at one spot, it could be very soft at another place in the audience. Therefore, we needed to compose the panning trajectories in such a way to create variety and balance across the hall, but at the same time accept that audience members seated in different parts of the hall would have very different experiences.

*4.1.2 Find new components and relationships in composition.* New situations can be mined for new musical material, and the performance situation of multifaceted presence is rich with opportunities if framed as such. By embracing the malleability of time and space, one can explore the nuances afforded, like we do in Clockwork, e.g. rooms being simulated and physical at different times, offering remote access to physical and simulated spaces, and acoustic coupling of physical and simulated spaces.

*4.1.3 Employ modelling as a way to work with site.* Be open to the possibilities of using models to simulate site, without stratifying them as real and virtual. Instead, simply consider them as systems that point to other systems, all equally real, equally valid, but with

different characteristics. This third point is of particular interest to us and will be used as a starting point for a suggested future research direction outlined in the next section.

### 4.2 An artistic modelling practice

In our work, we make use of linear simulation of rooms containing particular setups of loudspeakers and microphones. The work presented in this paper simply could not have been created without these models, by sheer practical circumstance. It should be noted that the term model is being used here to denote both the digital simulated room acoustics using convolution, but also the use of the Milstein Hall in the early work for Rundgång. If we look at a more extended idea of modelling, or perhaps rather the act of *formulating* a model and employing it to gain understanding of artistic concerns, it becomes clear that the term can be applied to almost every part of our shared artistic practice and research activities. One example would be our approach to signal processing - iteratively refined software models that connect to other physical, electroacoustic, digital, and social models, e.g. acoustics, loudspeakers and microphones, the networked world of servers, cables and satellites, or the performers and audience in a concert situation.

The conceptual and logical centre of Clockwork is the idea of the calendar, perhaps one of mankind's most pervasive and widespread models, bridging the celestial with the mundane. It contains practical, mystical, political, technical, and religious concerns and has manifested itself in a myriad of ways, e.g. as runic calendars, sun dials, almanacs, tidal-predicting machines or the Antikythera mechanism. By adding itself to that multitude, Clockwork becomes a comment on both the concept of the calendar as a model and the act of formulating models itself.

As a final note, the act of scientific reflection and analysis of observations spread out over a period of time can also be seen as a kind of formulation of a model. More precisely, it is a series of formulations of different models that are then evaluated, combined, refined and reformulated. The end result is a coherent system of thought where some actors are included and other not, some connections are emphasised and other omitted, all in order to propose a contained system that carries with it some aspects of the original material, that can be communicated to others. This framing points to many exciting questions concerning artistic practice and research that warrant further study.

## 5 CONCLUSION

In this paper, we have traced the usage of modelling through two composition processes, mainly in the sense of the simulation of room acoustics through digital and other means, essential for both pieces, but also in a wider sense, where the formulation of a model can serve as a general approach for many artistic endeavours. The first piece, Rundgång, was commissioned for a unique loudspeaker orchestra and creating it was only possible through extensive modelling. The second piece, Clockwork, was not only created using modelling, but also incorporates models into the piece itself.

The two pieces both embody the idea that a site-specific approach to musical composition can cater to a multitude of vantage points, those physically present in all their individual difference, and those otherwise mediated, without imposing a hierarchical order where some would be considered more real than others. This attitude enables a contemporary and relevant mode of artistic practice that elevates the meaning of presence and at the same time engages with all the ways presence can be experienced and understood.

## ACKNOWLEDGMENTS

This work has been supported in the context of the artistic research project *Inter_agency: Composing Sonic Human-Computer Agent Networks* (https://interagency.iem.at) funded by the FWF Austrian Science Fund (PEEK AR 483), and by the NAVET center at the KTH Royal Institute of Technology (https://www.kth.se/navet). We also thank Henrik Frisk and The Royal College of Music for allowing us to use the Milstein Hall, the *Re-Imagine Europe* project (https://re-imagine-europe.eu) and François Bonnet for commissioning Rundgång, and Trond Lossius for illuminating discussions about site specificity.

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