Nightports at Hull Minster: Transporting a Site-Specific Musical Work Across Physical and Virtual Spaces

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ABSTRACT

'Nightports at Hull Minster' is a musical project that harnesses spatialisation techniques to present music composed of the sounds of Hull Minster, UK, in both the location itself and alternative performance spaces, whilst still expressing the spatiality of the location. The root of the project is a live electronic music performance by Nightports (The Leaf Label), using only sounds recorded in the Minster itself, spatialised in real-time by another performer across a 25-loudspeaker array in situ. Three variant performance approaches are detailed that allow this original principle of spatialisation to endure in contrasting locations: a physical acousmonium in-situ; a hybrid acousmonium and virtualmonium; and headphone-targeted virtualisations for radio. The compositional and performance processes, influenced by architectural and acoustic considerations, necessitated the development of a scalable and adaptable spatialisation system by the Hull Electroacoustic Research Organisation (HEARO). Alongside the technical implementations, this paper details performance observations including the interplay between spatial dynamics, audience interaction, and sonic immersion, while also offering insights into potential refinements and advancements in the spatialisation methods.

1. INTRODUCTION

The initial concept and primary execution of this musical project involved a live electronic music performance within Hull Minster. The music was derived from sounds recorded in the bell tower, which were then diffused through a 'loudspeaker orchestra' array, utilising amplitude-panning to exploit the distinct acoustic characteristics of the space, following the fundamental traditions of the acousmonium: the intention of 'diffusing' signals across loudspeakers distributed in a performance space [1]. The resulting musical work is intimately entwined with the location: parts of the Minster date back to circa 1285 [2] and it features a rich, pronounced acoustic as to be expected of a large, stone church. The performance of the work requires three people – two triggering and manipulating sounds (referred to as Nightports or performer 1 or 2), and one gathering the various categories of sound feeds and spatialising them in real-time (referred to as the diffusion performer). Subsequent, unanticipated iterations of the project (for example, a live performance broadcast for BBC Radio 3) have required reactive adaptations of the spatial presentation and virtualisation of the acoustic properties of the Minster and the loudspeaker array that was implemented in the Minster in August 2022 [3].

2. ORIGINS

The origin of *Nightports at Hull Minster* was one of opportunity. Hull Minster is a welcoming public space at the heart of the city, but access to its bell tower is typically restricted. However, Nightports were granted rare access to the upper floors of the bell tower, where a complex arrangement of ropes and intersecting wooden beams converge to form the time-keeping apparatus of the structure. For centuries, the building has marked time for the population of Hull, with its bells reverberating across the city and out across the river Humber. This iconic building presents a fascinating challenge for the creation of new music because of its symbolic status, rich history and acoustic properties.

3. MATERIALS

In September 2021, a stereo and ambisonic recording rig was taken to the uppermost reaches of the bell tower, some 45 meters above ground level, up a narrow spiral staircase. The day was dedicated to capturing five categories of sounds: 1) individual bell tolls; 2) peals occurring at quarter-hourly intervals; 3) clock mechanisms; 4) mechanical noises of ropes in movement during peals alongside sundry metallic objects forming the fabric of the apparatus; and 5) a sample set of the 25-bell/2-octave carillon. This extensive palette of audio then formed the basis of an 8-month creative process which gave rise to a 30-minute ambient electronic composition designed for live performance, involving a mixture of pre-composed and improvised

elements, distributed across 7 stereo busses for discrete spatialisation via acousmonium-style diffusion.

4. COMPOSITION

First, the building as an architectural space carries with it its original intended function as a place of worship for the people of Hull (a factor that could be deemed a 'cultural' or 'dramaturgic' influence [4]). Since a significant refurbishment project that was completed in 2017, the use of the building has expanded to embrace non-religious segments of the population in a kind of ethos of celebratory welcoming. This wider use was reflected in the selection and organisation of musical materials: the preservation of the time-keeping function of the bells recalls the building's long-standing function, while invocations of the synths and beats of Berlin industrial music or ambient soundscapes work to 'break expectations' [5] of what the place might mean. Second, the acoustic properties (or 'physical' influence [4]) of the building were always intended to be woven into the fabric of the music and its performance. The music is thoroughly in and of that place, with sounds recorded at an earlier point in the building's history intermingled with those of the immediate, performed present to effect 'a kind of doubling or layering or space' [6].

There are two key compositional concerns here. First, a space is not simply a container for the intended future musical performance, it is a dynamic and integrated aspect of the compositional process that forms the materials in a teleological play of what may come to pass. The performers will not just play in the acoustic, they play with it. In this instance, as Elblaus and Eckel would suggest, 'without a site, there is no piece' [7]. Second, this sense that the acoustic would be an integral aspect of the music in performance exerted a natural limit on the possible density and intensity of any one moment. This impacted compositional decisions particularly with regards to percussion onsets and how sound could become obscured by pronounced acoustic responses. Though this was often unrewarding during the creative process, this sense of incompleteness was, in retrospect, some indication that this dialogue with space was necessary and inherent.

5. SPATIALISATION SYSTEM

The Hull Electroacoustic Research Organisation (HEARO) is a collective focusing on the creation and spatialisation of musical works based at the University of Hull, often utilising a loudspeaker orchestra. A bespoke spatialisation system, built within a modular software environment, has been designed to support traditional and diffusion techniques [8] and contemporary spatialisation approaches, akin to the 'BEASTMulch' software system [9]. This system encompasses functions such as loudspeaker array definition, input routing, virtual channel propagation, and mapping of physical controllers to virtual channel amplitudes. Adaptations were made for the Nightports at Hull Minster project to accommodate multiple stereo feeds for spatialisation: the system processes 14 audio inputs from Nightports, arranged into 7 stereo pairs, each transmitting discrete components of the musical arrangement to afford both musical flexibility and sympathy in the spatialisation approach (see Table 1). These inputs are propagated to 80 virtual channels, facilitating precise spatialisation across the loudspeaker array, with amplitudes controlled via diffusion performance interfaces.

Arrangement Component(s)	**Spatialisation Affordances**
Bass & Rumbles	Fixed
Drums	Anchored with widening dynamic across front of 'main ring'
Percussion FX	Dynamic across full array
Bells & Swells	Dynamic across full array
Synths & Pads	Dynamic across full array
Performer 1 Return	Fixed in 'diffuse ring'
Performer 2 Return	Dynamic across 'main ring' and 'diffuse ring'

Table 1. Arrangement components created by Nightports and the respective spatialisation affordances.

5.1 The Primary Array

In August 2022, a loudspeaker array based on the acousmonium principle was installed in Hull Minster (see Figure 1). It comprised 25 loudspeaker channels positioned to provide both envelopment and extension along the building's length, covering a 70-meter span. This primary array served as the basis for subsequent iterations, featuring eight large loudspeakers forming a main ring, six small, rear-facing loudspeakers for a diffuse ring, and eight small loudspeakers arranged in pairs for distant projection as a column. Three subwoofers provided low-frequency coverage, with additional ones used for extension. Time-alignment was implemented only within the nave due to significant delay compensations being required for the most distant portions of the array (~130ms).

5.2 Spatial Room Impulse Response Capture

An audio-visual format was adopted for online dissemination for the initial presentation of the project (as part of Freedom Festival 2022 in Hull, UK). A recorded live performance by Nightports was used, with virtual spatialisation applied in post-production. To achieve this, Spatial room impulse responses (SRIRs) were captured for each loudspeaker component in the Primary Array, excluding

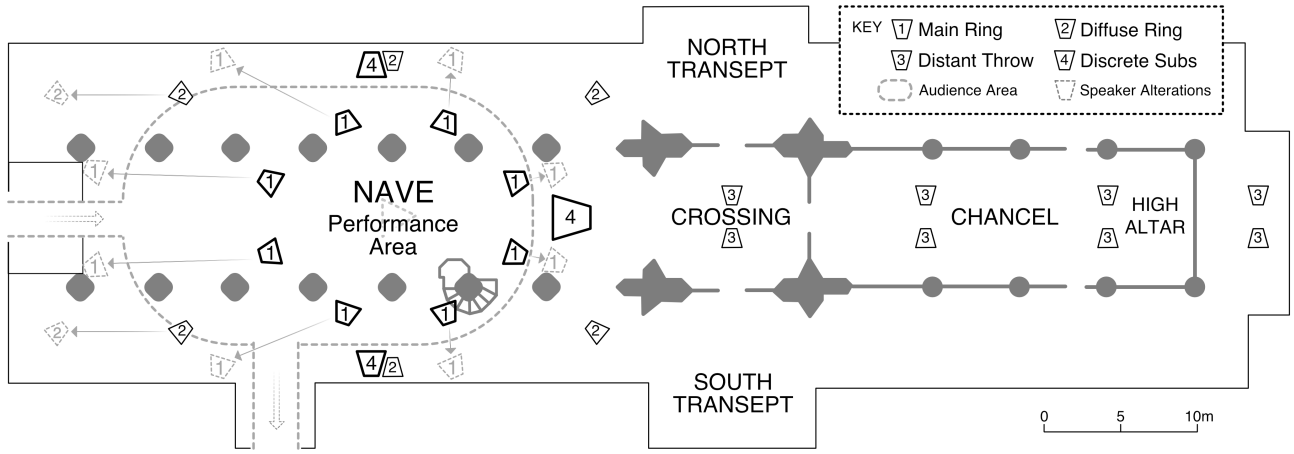

Figure 1. The primary array as realised in Hull Minster in August 2022 for a filmed performance, with alterations required for a realisation in March 2023, accommodating a public audience. [23]

subwoofers, using a 1st-order ambisonic microphone and the sine-sweep method [10]. These SRIRs facilitated ambisonic virtualisation through multiple convolution processes, utilising efficient non-equal partitioned convolution for near-zero latency processing [11].

6. PERFORMANCE INTERFACES AND AFFORDANCES

As the performance of the work would become unmanageable without a pragmatic approach to control design due to the number of sonic elements, the array of interfaces was selected to balance ergonomic efficiency with a degree of flexibility needed to maintain an improvisatory ethos. Performer 1 triggers the bulk of the pre-prepared sounds (which are organised into six blocks – roughly equating to six 5-minute segments) along with some software and outboard signal processor sends to be applied in the moment; performer 2 has responsibility for live synthesisers and the application of a range of signal processors to the sounds triggered by performer 1 to create another layer of processing. Outboard signal processors include reverbs and granulations, delays, noise and saturation. The performance is structured around the strict time-keeping function of the bell tower, beginning precisely on the hour, reaching the half-way point at exactly 15-minutes in, and culminating at half past. Within these main structural pillars (not unlike the columns, capitals and buttresses of the church itself) there are in-built places for improvised freedoms, which include addition and subtraction of audio elements within a texture, the intensity of send-return signals, and the combination of signal processing via pre- and post-fader configurations to further blur the source sounds.

The spatialisation of live materials in all settings was accomplished by the diffusion performer using a 32-fader OSC device and a MIDI device with XY controllers. These controllers manage virtual channel amplitudes, offering varying spatial control resolutions based on the intended spatial dynamics. Illustratively, the 'Bass & Rumbles' component is controlled by a single fader for overall dynamic amplitude, without spatial movement. The 'Drums' component employs two faders for amplitude control in a fixed position and optional broadening of the image across the 'main ring'. Meanwhile, the 'Synths & Pads' component utilises eight faders for front/back dynamic control and an XY controller for movement between the 'main ring' and 'diffuse ring', along with another XY controller for amplitude jitter control. This arrangement component model is consistently applied with slight variations across other components, enabling nuanced spatial control conducive to musical expression and performance variations. This spatial curation encompasses anchored/vectorial space, anchored/dynamic diffuseness, proximate/distal space, prospective/lateral space, and more [12]. The performance control resolution allows for a 'polyphonic', discrete diffusion of arrangement elements. A method was developed that allowed the diffusion performer to recall a snapshot of motorised fader positions that were devised for opportune moments between movements of the work. When recalled, an interpolation from the current fader position to the one predetermined is performed at a customisable rate. Any faders with active finger/thumb contact are excluded from the recall which enables dynamic spatialisation to continue simultaneously.

Adding this functionality created opportunity to choreograph some spatial movements that were unfeasible to realise with only performer input. An example of this is the staging of the clock mechanisms at precisely the quarter-past the hour point, featuring extreme close-perspective capture of the clockwork mechanism (accentuated with pronounced saturation and dynamics compression processing) set against a framing soundscape capture from the bell tower that brought external sounds of the city (vans reversing complete with warning beeps, traffic rushing, distant human laughter) inside the space. These specific

moments were structural markers, partly due to the sonic material, but also due to the spatial staging. These junctures emerged during rehearsals in the space and across the repeated performances as intuitively affective moments that were then recalled using the snapshot method explained above. Importantly, these moments were afforded by the musical materials in a dynamic and immediate relationship with the space – the structural scheme of the musical work was an emergent property in tandem with the architectural and acoustic resonance of the place. Finally, the recall method created an ecologically unlawful moment in the design of the sound because such sudden nonlinear changes (beyond the capabilities of a single human performer due to the physical realities of the body in relation to the sprawling bed of faders laid before them) created a perceptual 'jump cut' that was disorientating and self-signalling. These are ideal perceptual artefacts for important structural markers that the creators of the work want an audience to understand.

7. SPATIALISATION METHODS

The project has been realised (as both performances and recordings) in a variety of forms, which wasn't initially anticipated. The following is a summary of the key forms of realisation. In each case, the arrangement components have been performed by Nightports and spatialised by the diffusion performer in the manner outlined, which has supported a coherence across the different performance contexts. Three approaches are detailed: a physical acousmonium in-situ (A); a hybrid acousmonium and ambisonic virtualmonium [13] [14] (B); headphone-targeted ambisonic virtualisations (C1 and C2).

7.1 A: Acousmonium in-situ

A public performance at the Awakening arts festival in Hull, UK, in March 2023 represented the primary-intended context of the work. This implementation employed a conventional amplitude-panning approach for spatialisation. The spatial dynamics relied on the physical loudspeaker positioning within the Minster and real-time routing of arrangement components. Notably, adjustments were made to the loudspeaker array to accommodate the movement of a substantial public audience around the performance area (see Figure 1), leading to alterations in the response of the 'main ring' to be less direct and an increased reliance on elevated sound pressure levels.

7.2 B: Hybrid acousmonium and ambisonic virtualmonium

The HEARO loudspeaker orchestra was implemented in Middleton Hall, a concert venue situated on campus at the University of Hull, UK, as a 56-loudspeaker array utilising the acousmonium approach and higher-order ambisonic decoding via a 31-channel irregular array portion. This afforded a hybrid presentation of the project, which amalgamated amplitude-panning with real-time convolution of the Primary Array SRIRs. The performance by Nightports as recorded in August 2022 was used as source for a concert of real-time spatialisation in November 2022. The performance embraced an 'electroacoustic coupling' of the existing hall acoustic and a rendered simulation of the Minster's acoustic, akin to the 'active acoustic' method [15][16]. Notably, SRIR rotations were made to superpose with the equivalent loudspeaker positions in Middleton Hall where they existed, compensating for any discrepancies in array layout, supporting the 'electroacoustic coupling'. The resulting system provided precise control over both the direct and reverberant characteristics of each loudspeaker. For those loudspeaker sources intended to convey the spatial depth of the virtualised Primary Array, the decoded SRIR convolution feeds were used exclusively, ensuring accurate reproduction of distance-related auditory cues that were otherwise prevented by the contrasting shape of the concert hall. This methodology amalgamates techniques from both a conventional loudspeaker orchestra acousmonium and an adaptation of Barrett's virtualmonium, a loudspeaker ensemble rendered in ambisonics, crafting an 'augmented' auditory experience [17].

7.3 C: Headphone-targeted virtualisations

Two iterations of the project have exploited ambisonic virtualisation of the primary array for binaural stereo: a fixed-media audio-visual presentation of the work for Freedom Festival 2022 and a live performance for broadcast on BBC Radio 3.

7.3.1 C1: Fixed Media

The Freedom Festival 2022 film showcased a rendition of the project which harnessed 3rd-order ambisonics [18]. Recorded from a live performance by Nightports, post-recording spatialisation was applied via a native ambisonic method, emulating the primary loudspeaker array, akin to a virtualmonium. Signals intended for physical loudspeakers were redirected instead to two processing destinations: SRIR convolution for the reverberant response and a room encoder for a direct response emulation. These encoded signals were time-aligned and processed in a binaural decoder. The approach aimed to recreate the perceptual experience of the performance in the Minster more accurately than using SRIRs alone, which sounded too indirect. Spatialisation was performed in real-time by the diffusion performer, using familiar interfaces, with control data recorded for automation. However, the method's latency, stemming from utilising both modular and Digital Audio

Workstation (DAW) environments, rendered live performance an impossibility.

7.3.2 C2: Live Performance for Radio

A live performance of the work was recorded at the Trades Club in Hebden Bridge, UK, for BBC Radio 3's 'Northern Drift' broadcast. This performance, recorded in November 2022 and broadcasted in January 2023, featured live sources from Nightports and real-time spatialisation by the diffusion performer. To optimise responsiveness, the density of SRIRs and room-encoded loudspeaker positions was reduced, from 8 to 4 for the 'main ring' and from 6 to 4 for the 'diffuse ring'. This reduction in coverage resulted in a more efficient channel count and improved latency, critical for the live performance. The ambisonic signals were decoded to binaural stereo and aligned with selected non-ambisonic components (Bass & Rumbles, Drums). Performers monitored via headphones and utilised familiar performance interfaces, with the diffusion performer having the ability to dynamically rotate the ambisonic image across the azimuth.

8. PERFORMANCE OBSERVATIONS

There are six inter-related dynamics at play in the real-time exploration of the space during a performance: distance/proximity, diffusion/localisation, stasis/movement, clarity/noise, purity/distortion, focus/blur. These dynamics are the site of in-the-moment decision making, which elevates the performance from simple play-back of prefabricated sounds to a responsive, unique performance moment. They also relate to all modes of performance whether live multi-speaker spatialisation or stereo radio broadcast recording.

As part of the Awakening arts festival in Hull in March 2023, four consecutive performances were given starting at 6, 7, 8 and 9pm. A defining characteristic of the performance (which aligns with the ethos of the festival) was to permit maximum autonomy to the audience to move freely around the space. The nave of the church was clear of pews and other furniture, leaving a wide-open space from which audience members could pick a perspective or move between any part of the church. This free flow of people was made possible by utilising different entry and exit points to the venue. Over the course of the evening of performances, 3,800 people experienced the work. There was a sense of accumulating willingness for risk across this evening of performances as increased familiarity with the material and the space gave rise to an increased desire to explore how far (quite literally in the space) the performance could be taken, and how much noise the venue could withstand. The use of sends to pedals to distort and glitch sounds further became much more liberal in application and the whole effect was a form of sonic envelopment of and with the performance space. In short, the spatialisation became more dynamic as did the degree of intervention and treatment of the source audio.

In comparison to this, a performance for BBC Radio 3's 'Northern Drift' program (made in front of a live audience at a former working men's club in Hebden Bridge, UK) adopted a headphone-centric approach that was a markedly different experience in a way that was unexpected, and which challenged the location-specific purity of the original concept. The headphone version felt sonically 'pure' whereas the acoustics of the in-situ live performance, in comparison, had a quality of 'interference'. Additionally, when the work is taken outside of the Minster itself, the opportunity to manage the direct and reverberant portion of the loudspeaker array responses (in this case by simply balancing the SRIR-convolved and non-convolved signals) was considered creatively essential, if not aesthetically 'pure' in terms of the original concept. Each iteration outside of the Minster is a departure from the source situation and becomes an inflection of the work with qualitative contrasts because of the 'folding or doubling' of different spaces, but also provides novel opportunities for spatialisation.

The choreography of the spatialisations across iterations shared similarities, partly due to predetermined compositional cues and consistent means of control. While primarily lateral in nature due to practicalities and available resources, some loudspeaker angling and reverberation in the Minster extended spatial dynamics upwards. Middleton Hall's layout variation (spatialisation method B) introduced height dynamics, showcasing site-specific aspects and the project's adaptability across contexts while maintaining coherence through emulated acoustic properties and consistent means of spatialisation.

Ambisonic virtualisation offered certain benefits, including isotropic flexibility allowing rotation of array portions during spatialisation. This enhanced the sense of spatial movement across the 'main ring' in method C2 compared to C1, which lacked rotational affordance. However, transitioning to a virtualised and non-navigable perspective restricted the ability to explore the sonic environment through head movements, affecting localisation. While this may benefit performers' spatial experience, as it offers a firm grip on the presentation, it limits audience engagement spatially.

Monitoring the performance on headphones during method C2 also meant a sense of being removed from the social setting and entering an individual performance space. From the moment of putting headphones on at the beginning of a piece, the performers experienced the sudden attenuation of room and audience noise due to the closed-back and sonically isolating headphones being used. Sonic isolation was akin to social isolation. There

was no longer a shared soundscape between performer and audience. This resulted in the monitoring being detailed and highly accurate (revealing aspects of sound that had not been perceptible within the Minster performance (method A) due to the size of the building and location of, in particular, the very furthest speakers) but situationally abstracted. In the Minster, sounds were frequently moving around within the space and the performers could not fully be sure of the relative loudness of the parts they were playing as they could be positioned near or far away. As a result, the process became about intuition and returned the electronics performance imperative to one perhaps more like the proprioceptively-connected relationship between body and instrument. On headphones, where all performers and audience had the same mix, this seemed to create a more cautious approach to the balancing of each musician's parts as no one wanted to stand out or above the others.

9. TECHNICAL OBSERVATIONS & DEVELOPMENTS

While the SRIRs were limited to 1st-order due to inventory constraints, upmixed versions were generated [19]. However, employing a HOA microphone capture could potentially improve localisation and spatialisation methods, especially considering the density of loudspeakers in the array. The spatial impulse response rendering (SIRR) method [20] offers an alternative approach, exclusively utilising convolution for spatialisation and potentially enhancing localisation without the ambisonic decoding layer. It should be noted that the SIRR method, in the context of this project, would necessitate a considerable number of convolutions to be processed. For future headphone contexts, decoding/transcoding SRIRs or SIRR-processed SRIRs to emulated binaural room impulse responses (BRIRs) before convolution could reduce the number of convolutions and improve latency. This 'virtual ambisonic' approach [21] could also incorporate ambisonic interaural level difference optimisation (AIO) [22] for further perceptual benefit. While latency wasn't a significant issue in current iterations, it could become problematic for future musical variations that necessitate more responsive systems. Additionally, head-tracked implementations and user-navigable dissemination methods offer further potential for developing the spatial experience in viable contexts.

10. CONCLUSIONS

Given the initial aim of presenting a site-specific performance through an acousmonium in the Minster itself, the emergent opportunities of dissemination and performance required the creators to adjust the approaches to spatialised performance in a reactive manner, harnessing combined methods and techniques. This situation has raised inquiries about the significance of the acoustic origins of the work, the viability of transferring a live, large-scale, site-specific piece, and how these factors have influenced the execution of the performances. Additionally, the process of SRIR capture became essential to providing a viable method of transportation and is considered a critical component of the technical approach of the project. Although there is scope for refinements and extensions within each iterative version of Nightports at Hull Minster, the project highlights the potential for adapting and transporting a site-specific work that is otherwise entwined with a location's acoustic and architecture.

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