UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Room Tone to the Stratosphere: Investigating Sonic Substructures Through a Progression to Near Silence

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under the supervision of Dr Robert Sazdov and Dr Felicity Wilcox

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Author declaration.

CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Julius Ambroisine declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Creative Arts in the School of Communications in Faculty of Arts and Social Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Abstract.

This research uses sound recording and composition practice to investigate the lowest sound layers of selected soundscapes in a progression to recording as near to silence as possible. The field recording method used throughout the research uses a room tone recording approach taken from film production: an atmospheric sound recording of an interior filming location that avoids any primary sounds of anthrophony (human sound), biophony (wildlife sound), and geophony (geophysical sound). Composition based exclusively on the field recordings is then used to investigate the findings of the field recording practice using stringent compositional rules restricting sound processing to amplitude, equalisation, and noise reduction. The first step sees room-tone recording taken out of film production in an attempt to record near-silent rooms within an empty house and compose with the captured room-tone recordings. The same room-tone recording approach is taken outside and used during the 2020 Covid-19 lockdowns in the Sydney CBD to record the city in a state of quietude. Common city anthrophony was minimised through pandemic lockdowns presenting a unique opportunity to capture the removal of primary sound layers. The reduced sound levels made it possible to record the 'room tone' of the city, the lower-level sounds of city function usually masked by the louder sounds of traffic and people. Urban sound layers are then removed entirely by travelling to remote locations in the Australian desert to record an ancient soundscape. There, only the most fundamental geophony of gentle winds are recorded in an environment of extreme quietude. Finally, in an attempt to escape all sound on the ground, weather balloons are used to remove sound layers through altitude, recording through the troposphere, into the stratosphere and up to near-silence above the Ozone Layer.

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https://drive.google.com/drive/folders/1sSvz0g3jcZgU4o16UN5n9JAPc2s_S9Ql?usp=sharing

Introduction.

This practice-based research (Candy 2006) uses exploratory and novel methods in field sound recording and composition to investigate the lowest sound layers of our soundscapes through a progression to near silence. The investigation uses field recording methods to peel back layers of soundscapes to listen to the sonic substructure below the common, primary sounds, followed by an attempt to place microphones away from all sound. Composition is used to further examine, explore, and interpret the field recordings and findings of the recording process.

For this investigation I have separated the soundscapes into the following categories and terms:

- *Primary sound* refers to the common, recognisable sounds of urban and natural soundscapes, for example; cars, trains, planes, factories, construction, people, animal call, thunder, strong winds, rain, rivers, oceans.
- *Sonic substructure* is the lowest sound layer below all primary sounds in any soundscape. If all primary sounds could be removed the inevitable, unavoidable sonic substructure is what would be heard.
- *Near silence* is very low-level sound around 35dB SPL C weighted and below.

These contents of the soundscape are categorised using terms taken from Bernie Krause:

- Anthrophony: human sound.
- Biophony: wildlife sound.
- Geophony: geophysical sounds such as wind, water, thunder (Pijanowski 2011; Krause 2012).

In sound recording throughout this research, all primary sounds of anthrophony, biophony, and geophony, are minimised and, where possible, removed in order

to hear and record only the fundamental, sonic substructure of the selected locations. The underlying progression to near-silence forms the foundation of the research and is directed by sound recording concepts and practice. The progression moves from:

- an empty room
- to an empty house
- to a city emptied during Covid-19 lockdown
- to remote natural locations
- then to the stratosphere using weather balloons in an attempt to escape all sound.

The sound recordings gathered in the field aim to capture the sonic substructure of selected locations for investigative and compositional purposes, as well as to document the locations in the overriding narrative of the progression to near silence. The sound recordings submitted are an important aspect of this research. The recording intentions and process is creative, original, and difficult to execute, many of the recordings are considered pieces on their own. Long form recordings are used throughout to capture an abundance of the targeted quietude with limited interruption, ranging from twelve minutes up to three hours. For submission purposes some sound recordings have been shortened to focus on the relevant areas.

The compositions are based exclusively on the field recordings gathered and used to summarise and interpret the findings of the sound recording process. *Musique concrète* (Schaeffer 2012) approaches are used with strict compositional rules in place to maintain the integrity of the sound recordings and avoid any reliance on overt sound manipulation beyond removing system noise. A theme of reduction is explored in both sound recording and composition by focusing on the fundamental sound layer and the fundamentals of composition. These are studies in composition based on each of the research areas with the outcomes difficult to predict given the extreme quietude of some

locations, and the intentional limitations set in place for composition and sound processing.

The research questions asked through the progression are:

1. Is it possible to record rooms in a state of near silence and use these room tone recordings as the basis for composition?
2. What are the effects of reduced human presence on the Sydney CBD soundscape during the 2020 Covid-19 lockdowns? And what can be heard if we reduce primary anthrophony to focus on the fundamental sonic substructure of the city soundscape?
3. What is the sonic substructure of a natural soundscape found in the Australian desert?
4. Is it possible to place microphones away from all sound on the ground and record a true sonic silence in the stratosphere?

The submitted research outcomes are:

- A sound library of the Sydney CBD Covid-19 soundscape.
- A sound library of the Bourke to White Cliffs desert recordings.
- Two recorded weather balloon flights: segments of flight 2 in standard footage, and flight 3 in 360-degree footage in entirety.
- A collection of compositions from each chapter that summarises and interprets the findings of the recording process.
- Exegesis on the process and outcomes of the research.

Background.

The research begins in film and television production with my professional practice as a sound recordist and sound designer. It was while working in film that I developed the initial, key concepts to the research. The foundations are found in room tone recording from film production, an atmospheric sound recording of an interior filming location with all set design and lighting

equipment in place, and minimal external sound entering (Viers 2008). In the final sound mix room tone recordings provide a sonic bed to cover and fill any audible dialogue or sound effects edits that may divulge process and distract from the story (ibid.). In my work experience, room tone was also used to add dimension to a final mix by providing the fundamental sound layer of the room itself, creating the possibility to sonically recreate the room for further viewer immersion. A room tone may include gentle mechanical drones of an exhaust fan, the central heating and cooling system of the building, those of other surrounding buildings heard in the room, or the gentle din of traffic entering, but it is a generally unrecognizable, indefinable fundamental sound. A scene containing no dialogue filmed in a room seemingly without sound sources will still contain a layer of room tone to avoid unwanted digital silence and to sonically place the viewer within the room. There is never an empty space, empty time, or silence in reality (Cage 1968) and it must be avoided in film; a complete digital silence would be perceived as error (Figgis 1998). Some directors have explored the use of room tone in film by bringing it to the foreground and using it as an emotive tool in a manner similar to music. A prime example is David Lynch's use of room tone in his films Eraserhead (Lynch 1977) and Lost Highway (Lynch 1997); these examples use room tone to create suspense or a surreal, hyper real ambiance through sound design (Brophy 1997; Collins 2019; Rogers 2020).

Hidden, discreet sound is key in this research and room tone is one such sound within filmmaking. It forms the sonic substructure of a film's soundtrack, a seemingly empty, simple technicality found beneath the obvious primary sounds of dialogue, Foley, sound effects and music. But on further investigation room tone recordings alone are rich sound textures unique to each location and by focusing on such sonic details, a largely ignored background aspect of filmmaking is brought to the foreground. The visual becomes secondary to details of the sonic with mechanical drones, acoustic properties and resonances of interior locations prioritized. However, in my work experiences, the act of recording room tone during film production is always difficult due to the inevitable interruptions from unwanted external sounds and those made by the

film crew. The short recording process creates a time where the hub of activity of a film set is forced to stop and focus on a small yet important aspect of production sound; in my experience, it is frequently seen as an unnecessary annoyance and the film crew often does not come to the necessary halt for a successful recording. On film sets I found myself working in fascinating interior locations thinking it would be interesting to remove the film crew so I could record the sound of these rooms in isolation, then potentially compose with the different room recordings. Therefore, for a successful investigation into room tone, the technique needs to be taken out of film production.

Research Aims and Progression.

The first chapter in the progression, "Interiors – rooms in a state of placidity" sees the confines of film production removed to focus solely on room tone recording. Aspects including the film crew, time of day, and location selections based on visual not sonic characteristics are removed. A room tone recording approach is used to record the interior in a state of placidity and in its simplest form, allowing the room to be gently 'illuminated' (Blesser & Salter 2006) by only the most minimal external sounds entering. To capture the acoustic characteristics and gentle resonances alone, rooms are recorded late at night with minimal anthrophony or biophony, and only base-level geophony. The recording target selected was an empty, everyday suburban house; the resulting recordings are used in three short compositions that explore an empty room, and then an empty house. They aim to capture the sonic differences between rooms in the same house and compose with these. The question asked:

- Is it possible to record rooms in a state of near silence and use these room tone recordings as the basis for composition?

The second chapter sees the room tone recording technique taken outside. The approach is the same in avoiding any primary sounds to record the metaphorical room tone, or sonic substructure, of exterior locations. The first example is the inclusion of the Sydney CBD during the first Covid-19 lockdown in 2020. Here,

the Covid-19 pandemic lockdowns are used as a part of the recording method to remove the people and primary anthrophony of the city to listen to the sounds below. It provided a further yet unexpected step within the research progression to record and experience the very unique occurrence of removing primary sounds from a city soundscape. The questions asked being:

- What are the effects of reduced human presence on the Sydney CBD soundscape during the 2020 Covid-19 lockdowns? And what is heard if we can remove primary anthrophony to focus on the fundamental sonic substructure of the city soundscape?

The third chapter sees the same technique of room tone recording taken to exterior locations in the desert of New South Wales Australia. Primary sound layers of anthrophony, biophony and geophony are removed by travelling to remote locations of minimal audible wildlife and vegetation to record the most fundamental sonic substructure of our exteriors. There is no silence in the natural world therefore the questions asked are:

- What remains if we can remove all primary sounds and what is the sonic substructure of the natural soundscape?

The approach still follows room tone recording exactly and the sonic substructure is the recording target. It now becomes a nature recording technique searching to record a specific sound, this being near-silence in our natural world: an ancient sound that pre-dates the sounds of complex animal life forms and is an increasingly rare occurrence.

Finally, in an attempt to escape all sound on the ground, a novel sound recording technique using weather balloons is used to remove the sound layers through altitude; recording the troposphere, stratosphere, then near-silence above the Ozone Layer at altitudes of 28 – 33km. The final questions in the progression are:

- Is it possible to place microphones away from all sound on the ground and record a sonic silence in the stratosphere?
- Is it in fact silent in the stratosphere?
- If there is sound, where does it originate, and is sound perceived differently in the stratosphere?

Throughout the research, the layers of our soundscapes are gradually removed using exploratory approaches to sound recording in a progression towards sonic silence, investigating: interior spaces, city soundscapes and the Covid-19 pandemic, remote natural place, then the stratosphere. This is not an exhaustive study of each area; it is a practice-based investigation that is also intended to lay the foundations for further investigation.

Recording and Noise Reduction Methods.

Throughout the research stereo and ambisonic recording formats are used. Between these, stereo formats were deemed to best suit the research and sound recording aims in recording definition, system noise, resistance to wind, and size. For these reasons, only stereo recordings are submitted. Stereo formats consisted of small lapel-sized microphones; either Sanken COS11 (Sanken Microphones 2021) or Fel (FEL Communications 2021) omnidirectional microphones were used as spaced AB stereo pairs. Stereo sound recorders used were a Zoom H4n (Zoom 2014) and a Lectrosonics SPDR recorder (Lectrosonics 2021). For ambisonic recording a Rode NTSF1 (Rode 2021) microphone was used with a Sound Devices 788t (Sound Devices 2021) recorder and Zoom H6 (Zoom 2021), however, due to the susceptibility to wind and a lack of detail in recording the low-level sounds, the ambisonic system primarily functioned as a backup.

Many of the recordings gathered are of very quiet places and very low in level, creating problems in relation to system noise and signal-to-noise ratio, and in capturing finer details of the soundscape. To combat this, noise reduction is a priority. Noise-print recordings of all recording systems used are captured in the

anechoic chamber at the University of Technology Sydney Acoustic Labs. Throughout the research, recordings of system noise are used with noise-reduction software as either a reference when removing system noise by ear, or as a noise print for learnt reduction approaches (iZotope 2021a). When working by ear, the Waves WNS multiband noise suppressor (Waves Audio 2021) is preferred, when working with noise prints the iZotope Spectral De-noise (iZotope 2021b) is used. Noise reduction removes unwanted system noise from recordings to hear details of the recorded environment, and to prepare recordings for composition. Care is taken to remove only the noise of the recording system, leaving the recorded environment as untouched as possible. In some compositions here, noise reduction is at times over-used as a form of sound manipulation to create suppression effects or a hyper-real, artificialness in composition.

Chapter 1. Interiors – rooms in a state of placidity.

Introduction.

Interiors marks the beginning of the progression in recording and composing with near-silence by taking room tone recording outside of film production and removing all primary sound layers from a house. The recording and compositional approaches used throughout this research are first explored here and a foundation question of the research is investigated, this being:

- Is it possible to record rooms in a state of near silence and use these room tone recordings as the basis for composition?

More specifically, can room-tone recordings capture the sound of individual rooms so they may be used as the basis for composition? For example, can the sonic differences we hear between a hard-surfaced reflective bathroom and a soft-furnished absorptive bedroom be recorded without intentionally triggering resonance and limiting all primary sound, capturing only the fundamental resonance that illuminates the acoustic properties of each room? Is it then possible to treat two such recordings as separate sonic objects (Schaeffer 2012) and use these as the basis for composition?

First formulated during experience working in film, these practice-based concepts investigating interiors and room-tone recording form the basis of the research. In the room tone recordings used here, the first steps in peeling back the soundscape occur with all aspects of film production removed, and any primary sound avoided to record a room in a state of placidity and near silence. The recording target is the fundamental sonic substructure of the room and microphones are used to locate and capture this. An interior must be sonically illuminated for it to be heard, similarly to needing light to illuminate an object for it to be seen (Blesser & Salter 2007), and it is this inevitable illumination of interiors reduced to the lowest possible level that is the recording target. As John Cage observed, “There is no such thing as an empty space or an empty time.

There is always something to see, something to hear. In fact, try as we may to make a silence, we cannot" (Cage 1968 p.8), a medium for sound to propagate is always present and, unless a space is specifically constructed, sound will enter and create a room resonance based on the material make up and acoustic properties of the space. The investigation is continued after recording through noise reduction, dissecting the room recordings in preparation for composition, then through the composition of studies that further explore the room and recordings.

The submitted materials for this chapter consists of three studies:

1.1 *Gradualism (the additive approach).*
1.2 *Rapidity (the subtractive approach).*
1.3 *Walking Around an Empty House*

Research contextualisation – previous sonic investigations of interiors.

Previously, sound practitioners recording and composing with interiors have used sound triggers to produce resonance or included primary sounds. Densil Cabrera defines room resonance saying:

> It is the result of standing waves, vibrating within a solid body, or in an enclosed space, and thus reveals something of the size and substance of such bodies … acoustic resonance gives us a sense of an object's interior, or of its wholeness. (Cabrera 1997 p.109)

Alvin Lucier earlier observed "each space … has its own personality that tends to modify, position and move sounds by means of absorptions, reflections, attenuations and other structurally related phenomena" (Lucier 1979 p.112). It is this sonic personality of individual interiors that I focus on in this research. Similarly to Lucier's works that "explore the natural properties of sound and the acoustic characteristics of architectural spaces as musical objects" (ibid. p.112), the room tone recordings used become unique sonic objects for composition.

Works such as Lucier's *I am Sitting in a Room* (Lucier 1980) and Jacob Kirkegaard's *4 Rooms* (Kirkegaard 2006) centre on the resonance of rooms. Lucier records himself in a room reading aloud the instructions and intentions of the work, plays the recording into the room through loudspeakers, records the playback, then plays this new generation into the room and continues the process, in the final generations the room resonance has taken over from the voice, speech is the trigger for the room to become an instrument (Lucier & Simon 1980). Lucier explores the personality of the room through resonance and successfully presents this independently by removing speech through generations of recording.

Kirkegaard adopts Lucier's technique in *4 Rooms* (Kirkegaard 2006), an album of four works based on four abandoned spaces in the deserted town of Chernobyl. Kirkegaard takes Lucier's technique further by not using voice to trigger the resonance of space but instead uses a ten-minute room tone recording of the same space as the trigger. Kirkegaard plays this room tone recording back into the room over ten generations of recording (Kirkegaard 2017). The work is of developing textures based on the design and materials of the room itself. The title *4 Rooms* shows Kirkegaard's interest in identifying and capturing the individual resonance of each room. However, in both Lucier and Kirkegaard's work it is the inflicted resonance and its qualities that are the focus and not the room itself in a state of placidity.

Others have worked with quietened spaces with internal and external sounds entering, for example, John Cage's *4'33"* (Cage 1952) and the sound recordings within British artist and DJ Janek Schafer's installation *Vacant Space* (Schafer 2016). Through musical silence Cage famously emphasises extramusical sounds entering and those within the concert hall, and in doing so generates sound from a confused and at times frustrated audience, showing there is no silence and all sound may constitute music. As Cage said of the first performance:

> There's no such thing as silence. What they thought was silence, because they didn't know how to listen, was full of accidental sounds. You could hear the wind stirring outside during the first movement. During the second, raindrops began pattering the roof, and during the third the people themselves made all kinds of interesting sounds as they talked or walked out. (Kostelanetz 2003 p.65)

Salome Voegelin addresses the musicality of Cage's approach in the compositional silence and musical framing of the piece in concluding:

> The silence of *4'33"* is a musical silence not a sonic silence. Cage's interest in silence lies in establishing every sound within the musical register. It does not invite a listening to sound as sound but to all sound as music. The framework of the concert hall guides the listener towards that aim. (Voegelin 2010 p. 80).

In performance, *4'33"* allows all sounds and explores these as music, while acoustic properties certainly play a role, these are not the focus, nor is the concert hall in a state of sonic placidity. In an audio-visual installation *Vacant Space* (Schaefer 2006), Janek Schaefer uses the internal and external sounds of interiors to amplify his experiences of the late night, post gig calm of different spaces. As Schaefer says in a video on the work:

> I've been touring the world playing concerts and I always end up in spaces late at night when everyone has left the room, all different kinds of spaces, and then I sit there, and I just listen to how there is never silence and I love the way sound can travel around corners. You can here the car passing and some people having a chat outside and you have to picture them in your mind. So I wanted to use the kind of nothing, vacantness, about space and take it and amplify it. (Schaefer 2016)

This quietude is in stark contrast to the volume of Schafer's performance and lays a platform for a detailed listening within the space; details emerge and the background becomes the foreground. Schaefer focuses on the background and presents selected vacant spaces and all their sounds in immersive headphone audio with accompanying visuals. Sound controls movement and brightness of the image and they work as one to highlight and amplify the characteristics of these vacant spaces, "the installation reveals and celebrates their life without us present" (Schaefer 2016). But as Schaefer says, the recordings include primary

sounds such as a passing car, or people chatting to capture the authenticity of the space. The soundscape of the interior is observed including the anthrophony that enters, how it does so, and how it interacts with the space. Both Cage and Schaefer's work do not discourage primary sound or attempt to remove it in exploring a space, rather they bring attention to, observe, and celebrate the sounds within and those entering.

Eric La Casa and Jean-Luc Guionnet's *House I* form the album *Home: Handover* (La Casa & Guionnet 2014) contains three minutes of room tone that is a very quiet domestic interior, however it is more inline with a quiet room tone from film production and still intentionally allows external sounds. It also forms an introduction that functions as the initial fundamental room tone of a house on which dialogue, music, and other domestic sounds are placed.

Francisco Lopez explores interiors and sounds within large buildings in *Buildings [New York]* (Lopez 2001). Lopez records within buildings in New York City capturing only the mechanized sounds of buildings then presents these as a hour long composition that gradually moves from one location to the next. Lopez provides the locations in the linear notes (Lopez 2001) but encourages listening to the composition before knowing the locations for a full immersion into the sound matter. The resulting album is a sonic study of buildings that takes the listener through the hidden sounds within the massive structures. Here, human movement and external sounds are avoided in concentrating on and revealing hidden details of the building's internal function.

But these works based on interiors explore resonance, how primary external sounds enter and react within a space, and the sound of the background mechanics of buildings often masked by other sound. The intention in my work is to peel back all primary sound and explore rooms in their most fundamental state. To not inflict sound or focus on external sounds entering but minimise these as much as possible. Here, aural architecture - as discussed by Barry Blesser in *Spaces Speak, are you listening?* (Blesser & Salter 2007) - is investigated through recording and composition. Blesser's aural architecture

refers to “the composite of numerous surfaces, objects, and geometries” (Blesser & Salter 2007 p.2), holding similarities to Alvin Lucier’s notion of the “acoustic personalities” of spaces (Lucier 1979 p.112). But Blesser further examines the sonic nature of interiors and how we experience them. Even though the ability to hear the spatial attributes of interior spaces is in all of us, in architecture and our everyday interior environments “the native ability of human beings to sense space by listening is rarely recognised” (Blesser & Salter 2007, p.1) and often abused. “Consider dining at an expensive restaurant whose decorations evoke a sense of relaxed and pampered elegance, but whose reverberating clatter produces stress, anxiety, isolation, psychological tension, undermining the possibility of easy social exchange” (ibid., p.3). Blesser gives further example of our sonic understanding of space in: “when blindfolded, nearly all of us can approach a wall without touching it just by attending to the way the wall changes the frequency balance of the background noise” (ibid., p.1). We can hear our interiors, and by listening to the sound of open doorways in a dark house late at night, our footsteps, or the intentional clicks used by the blind, we can sonically navigate an interior (ibid.). However, in order to do so, the interior must be sonically illuminated by background sound or triggers for the aural architecture to be heard, similarly to needing light to illuminate an object for it to be seen (ibid.). It is this inevitable illumination of interiors reduced to the lowest possible level excluding mechanical sound that is investigated in this research.

However, one final Lopez work of important exception in regard to this research is *Warszawa Restaurant* (Lopez 1995), a work I discovered after the completion of my own compositions. But in staying true to the approach of an immersion into sound matter (Lopez 1998), there is limited available information on the recording and composition to know how these rooms were recorded. Whether there are appliances such as fridges and air conditioners included or if these sounds have been intentionally excluded, or if there are significant external sounds entering and creating resonance? Where were the microphones positioned, were they placed to capture the sound of the interior as a whole or placed down in a corner for example to emphasis and capture lower frequencies? What, if any, sound processing has been applied in composition? Is it a study of

the sounds of low volume mechanical operation, or of the acoustic properties and resonance of the space? However, the level of system noise in the recording does indicate it is a quiet space and these are low-level recordings seemingly largely unprocessed. Regardless, while it is difficult to know what the sound sources are, it is an album that skilfully investigates composition with near silence and musical silence using the fundamental sounds of interiors, exploring the incredibly rich sonic detail of an interior soundscape at these low-levels. As one reviewer says:

> It was a work of almost intimidating quietude, a record so withdrawn that it seemed to suck you into a space of radical inwardness. In many respects, Warszawa Restaurant summed up the search for new modes of expression at the threshold between silence and sound like no other piece before it. (Fischer 2012)

Composition.

1.1 *Gradualism (the additive approach)* (3:40)
1.2 *Rapidity (the subtractive approach)* (2:00)
1.3 *Walking Around an Empty House* (3:09)

These interior based compositions set the direction and overall approach for ensuing composition throughout this research. Concepts of reduction are first put into practice here with composition used as a means to further explore and summarise the recorded soundscape and sonic substructure of each location. These compositions are short studies that explore the sonic substructure and possibilities in recording and composing with empty, near-silent rooms. To work with interior spaces in such quietude with strict self-imposed limitations is a difficult and unique approach that is embraced in order to maintain authenticity to the sound of the room and the original recording. Here, we begin within a single room and then progress to a house.

In composition, room tones are gathered in an empty house of common everyday rooms. The soundscape is peeled back and reduced to the fundamental: the house is empty with all internal sound sources removed, and each room is

recorded late at night with no wind or rain to avoid primary anthrophony and geophony. Recordings are approximately one hour long so any primary sounds can be edited out with enough quietude remaining. Once prepared for composition using equalisation and noise reduction approaches detailed below, samples of the quietest sections of the room tone recordings are captured as the materials for composition. The sound association of an empty, near silent room is not lost, however once in composition the appearance or purpose of the room is not important, it is the sonic elements, characteristics, and subtle differences that are the focus as the room is reinterpreted. Samples are repeated, layered, and looped similarly to Schaeffer's concrete approach in *Etude aux Chemins de Fer* (Schaeffer 1948), a study composed entirely of train sounds recorded at Batignolles railway station Paris (Schaeffer 2012). On repetition Schaeffer states:

> If I extract any sound element and repeat it without bothering about its *form* but varying its *matter*, I practically cancel out the form, it loses its meaning; only the variation of matter emerges, and with it the phenomenon of music. (Schaeffer 2012 p.13)

And this is the approach to the room tone samples, one that follows Schaeffer's two preliminary steps in working with sonic objects:

> *Distinguishing* an element (hearing it in itself, for its texture, matter, colour.)
> *Repeating* it. Repeat the same sound fragment twice: there is no longer event, but music. (Schaeffer 2012 p.13)

In the three compositions below, through repetition the samples of room tone are heard for their matter in a composition that explores and reinterprets the sound of a room. An approach of reduction is taken with four fundamental rules in place to enforce this and uphold authenticity to the room tone recordings.

These are:

1. Room tone used must be recorded in a state of complete placidity with no intentionally inflicted sounds to trigger resonance.

2. Room tone recordings must not contain any distinguishable primary sounds.
3. Room tone is the only material that can be used for composition.
4. The only parameters allowed for sound manipulation and composition are: equalisation, amplitude, and the length and placement of the room tone samples. No volume fades or automated panning created in the mix is allowed.

Playback and listening environment.

Playback volume is important, these are pieces based on room tone recordings that by nature are very quiet with the locations recorded reading at approximately 35 – 45db SPL C-Weighted. If listened to at a loud volume they may bare similarities to materials for a noise piece by, for example, Japanese noise artist Merzbow (Merzbow 2002), the samples can be abrasive as they appear from the musical silences. But when listened to at a lower level that approximates the location and the level of a room tone recording, they are pieces of subtle developing textures. This listening and compositional approach is partly inline with the Onkyo movement that began in Tokyo in the late 90s:

> typically performed with electric or electronic instruments, and its performance is often predominated by silences and pauses between sparsely placed singular sounds. In fact, *onkyô* concerts are often so quiet as to place an emphasis on the environmental sounds of the performance space, and players minimize expressive physical gestures. (Novak 2010 p.36)

This quietude in performance and composition was also in part attributed to:

> Some musicians claimed that *onkyô'*s performance aesthetics sprung from Off Site's physical limitations. The space was so small and close to other houses as to require quiet performances, since neighbors would complain if sound leaked through the thin wooden walls. The quietness of the space became a hallmark of *onkyô'*s performative silence, as well as the special kind of listening associated with the genre, as audiences came to Off Site prepared to listen with deep concentration. (Novak 2010 p.39)

There are also similarities found in lowercase music (Batchelor 2013; Hofer 2014), specifically Bernhard Gunter's *Un Peu De Neige Salie* (1993), an album of glitching high frequencies, hissing noise, and barley audible low frequencies. James Saunders describes the album in interview with Gunter as:

> a reduced palette of glitch sounds, working with highly detailed textures which have an innate complexity. Günter's approach foregrounds aspects of sounds that otherwise go unnoticed. (Saunders 2009 p. 271)

In the same interview Gunter says of his music:

> attention is becoming a rare thing in the modern societies of our days – a never ending stream of stimuli is directed at us by those who want to make us consume their products … what I'm trying to do is to create sound work that invites people to pay attention instead of aggressing them, something they can lean into, rather than recoil from it. (Saunders 2009 p. 273)

Further on this notion "I still prefer lower volume settings, because I do not wish to force my music onto anybody, as it is often done with popular music " (Freeman 2000). The following compositions in this chapter should also not be forced, they should exist within the listening environment and not overpower. Similarily to Onkyo, I feel they are best listened to at a lower level and in a quiet environment. This assists in representing the sonic details as heard on location and as they are intended to be heard in composition. It also follows sound recordist Chris Watson's approach to playback, that is, to listen to recordings at a level that resembles the level of the location to maintain some authenticity (Watson 2017). In this case it is a quiet room.

In the first two compositions specifically, samples appear from compositional silences that allow an interaction between the listening environment and composition. The subtle nature of the pieces call for a detailed listening that also brings to attention details of the listening environment. The extended rests present the sonic canvas the samples come from and the listening environment is the canvas. If the environment is loud and intrusive the listener will strain to hear the composition, bringing to attention the volume and interruptions of the

surrounding soundscape. As Voegelin says, “When there is nothing to hear, so much starts to sound” (Voegelin 2010 p.83). In this regard, the composition represents the everyday noise levels and filtering people undertake in urban areas of dense anthrophony. Comparatively to trying to comfortably converse in a loud restaurant or café of poor acoustic design, we have to filter out the environment to listen to this composition. If listened to in a living room on a busy street the external anthrophony will enter, become prevalent and interrupt. The listener is asked to filter the external sound but the composition’s subtleties make this impossible and surrounding noise is accentuated. If listened to within an everyday but quiet room, the samples of the recorded room tone interact with the room tone and acoustic personality of the listening room, the room tone of the listening room is the canvas. However, if listened to through headphones in a specifically quiet environment or through loudspeakers in a sound studio, this much quieter canvas provides a stronger platform for hearing the opposition and contrasts between the samples. Musical silence is more prevalent at the opening of each composition to allow a focus on the details of the initially small samples and their relationship with the soundscape of the listening environment.

Gradualism **and** ***Rapidity*****: room tone recording and frequency bands.**

In these two compositions a single room in an empty house is recorded and used as the basis for composition, the room is sonically taken apart then put back together in an altered state. Composition is influenced in part by Piet Mondrian’s Neo-Plasticism (Mondrian 1926), Walter Asmus’s production of Samuel Beckett’s *What Where* (The Writing and Society Research Centre 2016), and Sachiko Matsubara’s solo and collaborative works that sit within the Onkyo and lowercase movements.

Room tone recording.

A recording of an empty, high-ceilinged room with wooden floors and plastered walls is recorded in stereo with microphones positioned in the centre of the room. The house has been emptied and sonically reduced after moving home

with all sounds associated with living removed. The recording was captured late on a still night to limit exterior anthrophony and geophony, with any primary sounds edited from the recording. The hard surfaces and dimensions promote the inevitable sonic illumination of the room's acoustic properties. The room is of course not silent. The target and resulting recording is of the sonic substructure of the room made up of this gentle sonic illumination created only by inescapable fundamental geophony and anthrophony that always resonates within the room. At this lowest level, these are not distinguishable primary sound, rather distant and general rumbles or hums that become a fundamental layer when they enter the room. The room is left alone, resonance is not manually triggered or encouraged, but limited through time of day and still weather conditions. The sound of the room is brought down to the fundamental through placidity, the empty room is left to be and only the sonic substructure remains.

These are very low-level recordings and system noise needs to be removed. Noise reduction is based on noise prints of the recording system gathered at the University of Technology Sydney Acoustic Lab anechoic chamber. These are used to isolate and eliminate system noise but avoid removing any of the recorded room tone. A Waves WNS multi band noise reduction plugin (Waves Audio 2021) is used to reduce system noise subjectively by ear, while the iZotope Spectral De-Noiser (iZotope 2021) is used to attempt a more objective approach to reduction using a noise print.

Figure 1: the room recorded

Figure 2: reverse angle

Separating the room into frequency bands.

The first step of composition sees the single room tone recording separated into six overlapping frequency bands using equalisation. Each frequency band focuses on the separate acoustic personality of the room with two extremities at each end of the frequency spectrum. The six bands are named: Subs, Lows, Low Mids, High Mids, Highs and Upper Highs, these are not precisely named to match the frequency range but more so to suit my composition process. The Subs are an addition at the lowest end of the spectrum that makes the subsonic frequencies in the recording audible. The Lows cross over from the Subs and accentuate lower frequencies that are present but not easily heard in the original recording. The Low Mid frequencies are audible but play a supporting role to the High Mids, which are the core of the room tone and the most dominant frequency group in the original recording. The same sequence now occurs but in the opposite direction with the Highs audibly present in the original recording but accentuated here. Finally, the addition of the Upper Highs focuses on the brilliance of the room but also the inevitable high frequency system noise that always remains and emphasised when increasing the amplitude of such low-level recordings. These six frequency bands separate the room into the six timbres for composition. All frequency traits of the room are laid bare, made audible, and become equal through separation and equal volume. Sonically the room now becomes flat in preparation for composition. Through this approach to equalisation, the room is altered and acoustic properties not usually heard are emphasised. The sonic substructure of a simple room is explored in detail through a sonic dissection.

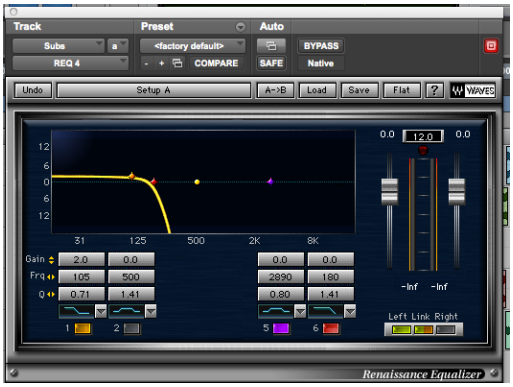

Figure 3: subs frequency band

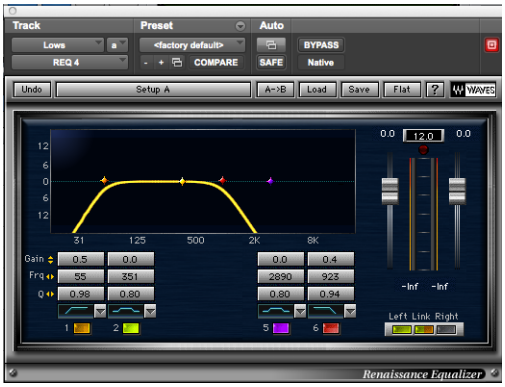

Figure 4: lows frequency band

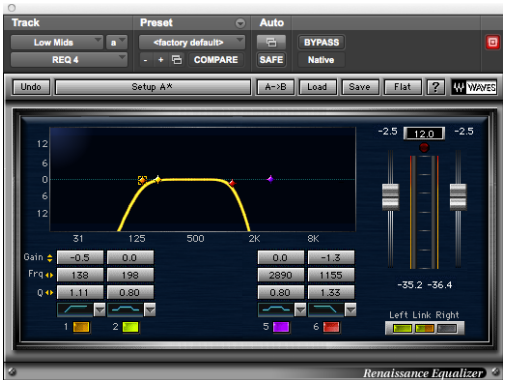

Figure 5: low mids

Figure 6: high mids

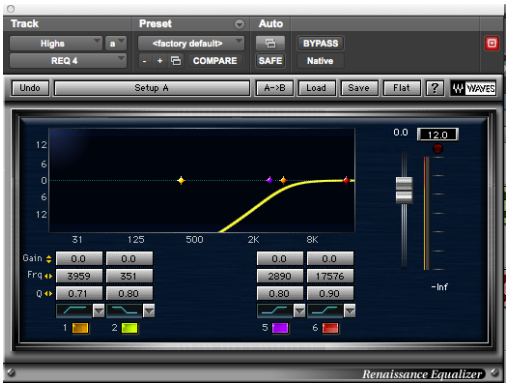

Figure 7: highs

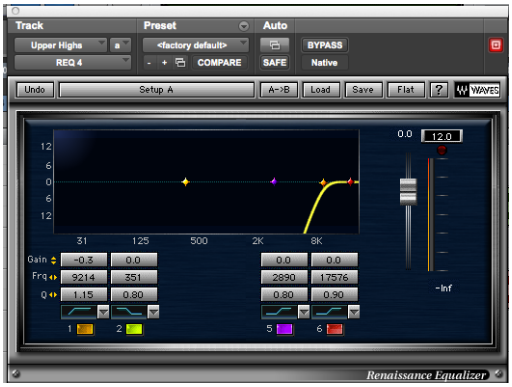

Figure 8: upper highs

In recording, the rooms are sonically reduced to a fundamental state, then in composition they are dissected, dimensionally flattened, and reinterpreted. Musical silences are the canvas from which samples of the sonically divided room tone develops. The two versions are based on additive and subtractive approaches that follow the extremes of gradual and rapid development. The additive approach of *Gradualism* sees small fragments of a divided room tone recording added to an empty edit, while the subtractive approach used in *Rapidity* sees these recordings imported into the edit in their entirety and sections subtracted from the waveforms.

Gradualism (the additive approach) **(3:40).**

This first approach used in *Gradualism (the additive approach)*, focuses on the minimal use and exact placement of samples from each frequency band added to the empty edit timeline. The room is separated into frequency bands, then using samples that gradually increase in size and occurrence the room is put together

in a new interpretation. The samples and frequencies gradually layer becoming more frequent, exploring and revealing the room through repetition of single fragments, then the doubling of fragments, then finally triads of fragments, until the room is returned in an altered form of separated, compressed frequency bands of equal volume. To fade the room and end the composition, the bands are removed until a final band ends the piece. Compositional aspects found in the Neo-Plastic works of Piet Mondrian, Walter Asmus's *What Where* (The Writing and Society Research Centre 2016), and works by Sachiko Matsubara are first investigated here.

Piet Mondrian is an influence outside of music for his methods of reduction in painting. I found similarities in composition that led to an investigation of Mondrian and an eventual further influence. His Neo-Plasticism focused on a reduction to the essential underlying elements of painting:

> Neo-Plasticism was in fact an ideal art in which the basic elements of painting – colour, line, form – were used only in their purest, most fundamental state: only primary colours and non-colours, only squares and rectangles, only straight and horizontal or vertical lines. (Tate Modern 2020)

Mondrian's method and progression towards reduction and purity is summarised in his General Principles of Neo-Plasticism (Mondrian 1926), an essay defining the Neo-Plastic approach to colour, line, form, relationships of opposition and equilibrium. The six principles being:

> 1. The plastic means must be the rectangular plane or prism in primary colors (red, blue, and yellow) and in noncolor (white, black, and gray). In architecture, empty space can be counted as noncolor, denaturalized material as color.
> 2. Equivalence in the dimension and color of the plastic means is necessary. Although varying in dimension and color, the plastic means will nevertheless have an equal value. Generally, equilibrium implies a large area of noncolor or empty space opposed to a comparatively small area of color or material.
> 3. Just as dual opposition is required in the plastic means, it is also required in the composition.
> 4. Constant equilibrium is achieved by the relationship of position and is expressed by the straight line (boundary of the pure plastic means) in its principal, perpendicular opposition.

> 5. Equilibrium that neutralizes and annihilates the plastic means is achieved through the relationships of proportion in which they are placed and which create vital rhythm.
> 6. Naturalistic repetition, symmetry, must be excluded. (Mondrian 1926)

While the two compositions *Gradualism* and *Rapidity* do not follow these six principles exactly, it is the overriding themes of reduction, equivalence, equilibrium, opposition, and space that are appropriated in composition. This is first evident in the room tone recording process where primary sound is peeled back through time of day and the room is reduced to the fundamental sonic substructure. It is continued in postproduction preparations for composition in which all primary sound is removed from the recording, and equilibrium is gained across the frequency spectrum through the separation of the room into frequency bands of equal volume, here the room is reinterpreted and flattened. Then similarly to Mondrian's reduction to the fundamentals of painting using line, primary colours and non-colours, sound processing is reduced to the fundamentals of amplitude, equalisation, sample length and placement. In composition, the samples are placed to create a gradual and equal development over the six frequency bands with the room reinterpreted in a fragmented and altered state. The musical silences function as the canvas for the contrasts between samples to be displayed through their interactions and opposition, and by also allowing the listening environment to become part of the composition.

Gradualism is a sonic investigation and reinterpretation of a room through dissection and reformation in which parallels can be drawn to Mondrian's work. *Composition 10 Pier and Ocean* (Mondrian 1915) is an investigation of rhythm and a fundamental reinterpretation in which "frequent short crossings of vertical and horizontal lines" (Fallazadeh & Yousof 2019) are used to create an interpretation of the pier and ocean. "This rhythmic abstraction reduces the rhythm of the waves and their breaking to a pure and simple pattern of lines, each precisely determinate in length and interval, like notes in a musical score" (Artlyst 2014). In *Gradualism* the room fragments are akin to Mondrian's waves of short lines; the room is sonically reduced, separated, and then reassembled as

a musical study through carefully positioned samples that form an interpretation of the room.

In early drafts, more frequent samples of varying levels were used along with volume fades and panning, resulting in an outcome comparable to the seemingly suspended coloured planes emerging from the white canvas in Mondrian's 1917 *Composition III with Colour Planes* (Fallazadeh & Yousof 2019 p.7). To remove this suspension and emergence, Mondrian added long vertical and horizontal lines to his work, first seen in *Composition with Colour Planes and Grey Lines* (Fallazadeh & Yousof 2019 p.7). This use of line brought his works closer to the fundamental and equilibrium by removing the notion of background and foreground (Fallazadeh & Yousof 2019). Similarly, *Gradualism* is levelled with all samples of the same amplitude, heavily compressed, and positioned static in the stereo spectrum to achieve equilibrium across the composition.

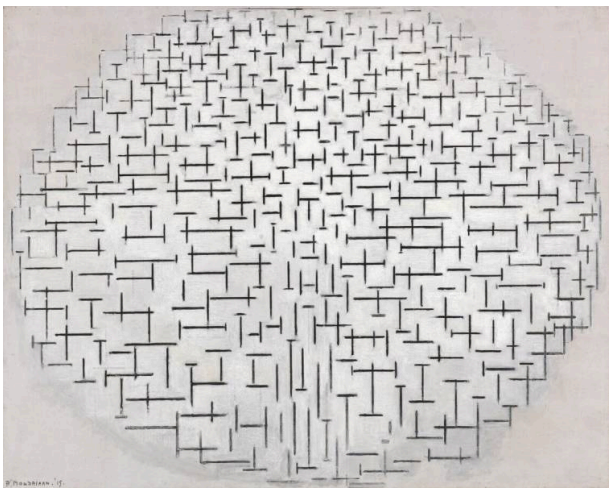

Figure 9: Composition 10 Pier and Ocean, Mondrian 1915 (Kroller Muller 2020)

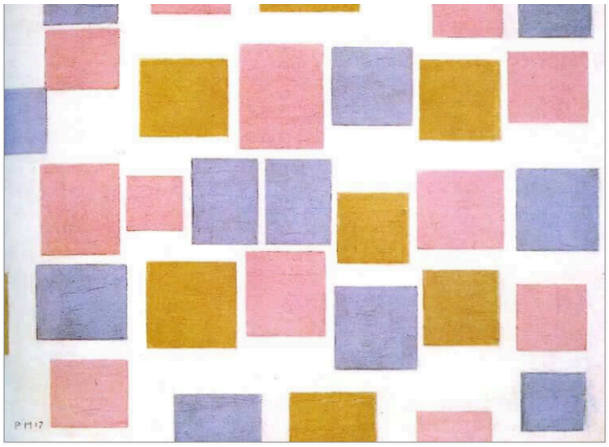

Figure 10: Composition III with Colour Planes, Mondrian 1917 (Fallazadeh & Yousof 2019 p.7)

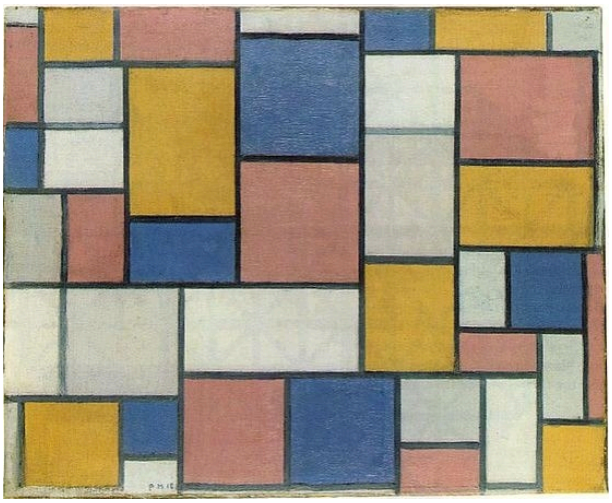

Figure 11: Composition with Colour Planes and Grey Lines, Mondrian 1918 (Fallazadeh & Yousof 2019 p.7)

However, *Gradualism* is a musical composition and there are of course differences in approach to Mondrian's painting. Samples are repeated following Pierre Schaeffer's notion of repetition to create musicality (Schaeffer 2012), and at times samples are symmetric creating chords to maintain elements of musicality that explore opposition and differences between samples, double stops and triads are used as the room is gradually revealed in an altered state.

Mondrian's influence is two-dimensional while Walter Asmus's *What Where* (The Writing and Society Research Centre 2016) is an initial source in regard to the placement and timing of fragments. *What Where*, first written and directed by Samuel Beckett as a theatre production and then film, explores interrogation and torture using a repeated dialogue delivered by actors showing only whitened faces on a black background.

Figure 12: still from the 2013 production of What Where (The Writing and Society Research Centre 2016)

I was introduced to Walter Asmus's 2013 film version in a professional role as a sound recordist and sound designer on the production. Asmus meticulously directs the actors in the timing and delivery of the dialogue, conducting numerous takes of the entire eleven-minute piece to capture the desired option for post-production. Asmus was careful to follow Beckett's original intentions: the delivery of the dialogue must be consistent and equal, measuredly placed in the dark along with the close up of each characters face (The Writing and Society Research Centre 2016). The sound and image gradually appear from the dark canvas of the film, the use of compositional silences provides the time and space

for the dialogue. As Asmus states Beckett was interested in "reduction, reduction, reduction, getting rid of everything which was redundant" (The Writing and Society Research Centre 2016). The delivery of the dialogue "must be very simple, it must be very straight, it must be very much on one tone" (The Writing and Society Research Centre 2016). And that is also the approach with *Gradualism*, the room is reduced to frequency bands and fragments with all parts equal, following this the placement of fragments in the compositional silence is equal, precise, measured and mechanical.

Japanese experimental musician Sachiko Matsubara brings the concepts and approaches above together in a musical sense. Composing and performing as Sachiko M, Matsubara works with a sampler filled with sine tones and test tone generators (Loubet 2000).

> Her world is that of concentration and timing—a captivating, reduced world, which she considers to be the antithesis of the Bubble Economy aesthetic, which is characterized by a blind accumulation of goods, sounds, and memory. (Loubet 2000 p.23)

After a previous collaboration with Otomo Yoshihide in the group Ground Zero, in which she played sampler, Matsubara moved away from traditional sampling saying "Sampling must be composed largely around a meaning, conveying a message, where as sinusoidal waves are nothing more than sound" (JaME 2009). Matsubara reduces the sampler to the pure tone of sine waves in improvisation:

> Her work is entirely spontaneous and relies on the meticulousness of the quality of the sounds, their texture, amplitude, displacement, appearance and fading. Silence is of equal importance in her work and is treated in the same way as the different signals that she handles. (JaME 2009)

In *Bar Sachiko* (Matsubara 2004), the constant laser like tones alter with the slightest movements of the listener's head and the progression in the composition of the three sine tones is very gradual. It's a reduction of the instrument to pure tones. Matsubara primarily works solo because she "doesn't need other external sounds" (JaME. 2009) but a collaboration with Ryuichi Sakamoto *Snow, Silence, Partially Sunny*, *Snow, Silence, Partially Sunny*

(Matsubara & Sakamoto 2012), sees sine tones and piano combine in an improvised performance. Matsubara's sine tones provide a constant centre with glitching embellishments, with Sakamoto's piano played around these plucking or brushing the strings, then later as a continuing metered progression of chords. Similarly to *Gradualism*, there is a gradual progression, the use of individual small sounds to begin then eventually chords, time is allowed for evolution with ample space in the composition.

The album *Salon de Sachiko* (Matsubara 2007) holds additional examples of reduction using shorter fragments of glitching sine tones played over system noise, or at times punctuating long musical silences, Matsubara's placement is central as they briefly appear as single sounds or in flurries. Further reduction using musical silence and gentle fundamental textures is in duo with Otomo Yoshihide on the album *Filament 1* (Matsubara & Yoshihide 1998), specifically *Track 1* and *Track 10*. Record label Extreme declares Filament "have managed to deconstruct electronic music to its very, albeit fragmented, essence" (Extreme 1998), while Loubet summarises they are "rejecting music as commodity to return to a simple, direct, and focused communication" (Loubet 2000 p.23). Yoshihide follows a similar vein of reduction to Matsubara in which "his current sound embraces simplicity and texture over dynamism and instrumental virtuosity" (Yoshihide 2014), and it is this aspect of his playing that is heard in collaboration with Matsubara. Yoshihide says of Filament "We removed performance and musicianship very carefully" (Extreme 1998). *Track 1* (Matsubara & Yoshihide 1998) begins with small clicks spaced 10 – 15 seconds apart, after one minute looped record static builds and provides a fundamental that is later punctuated with short sine tones. Further to the extremes of compositional silence is *Track 10* (Matsubara & Yoshihide 1998). As David Grundy summarises "Depending on one's frame of mind, this is either going to come across as soporific and eminently ignorable, or as edge-of-the-seat stuff" (Grundy 2012 para. 5). The composition is twice as long as other tracks allowing longer silences punctuated by small busts and glitches of sine tone, the short fragments break the tension created by long silences. These approaches to musical silence, space, and time are most reflected in a condensed form in

Gradualism in the placement of samples, and gradual progression of the room being pieced together. This approach to reduction echoes Matsubara's works of limited instrumentation, small fragments of sound, and long compositional silences.

Composition of *Gradualism* was ongoing over numerous drafts with the number of fragments, timing and placement of each fragment, and rhythm continuously adjusted until the piece developed the desired equilibrium within a gradual progression. Reduction is key, fragments are of equal value, repeated equally, and placed exactly to create a slow progressive investigation of the recorded room and listening environment. Following the four rules outlined above, composition is reduced to the fundamental characteristics of sound processing and composition using only: equalisation, volume, length and placement of fragments. As Mondrian uses only the elements of painting, Asmus aims for a mechanical and reduced performance, and Sachiko Matsubara uses sine tones and silences, *Gradualism* is reduced to the fundamentals; firstly in peeling back sound layers in room tone recording, in using the room tone recording alone as the basis for composition, and then in the use of reduction in composition.

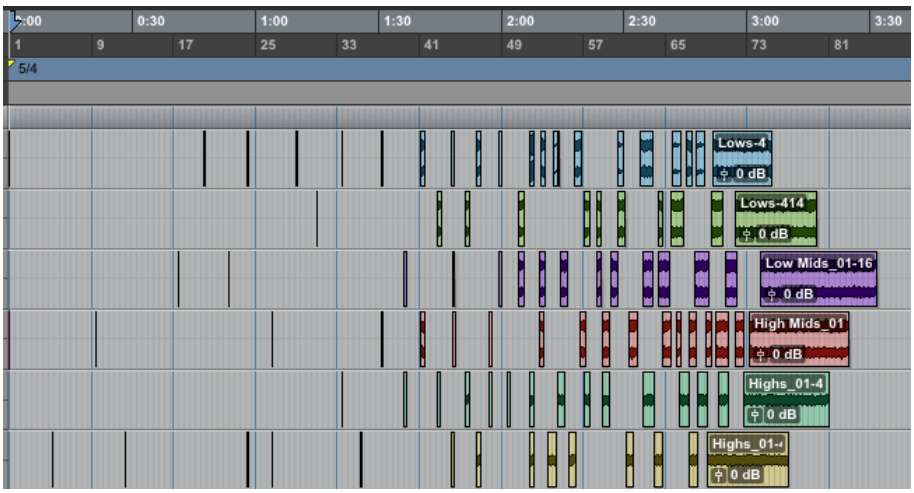

Figure 13: Gradualism Pro Tools edit.

***Rapidity (the subtractive approach)* (2:00).**

All the fundamental concepts above remain but this alternate approach concentrates on rapid, numerous, and frequent fragments that become whole again. Additionally, this approach contains elements of Henri Pousseur's *Scambi* (1957), primarily for the use of flourishes of single fragments of white noise in composition. The development from *Gradualism* to *Rapidity* in part follows Mondrian's progression to the later New York City works *Broadway Boogie-Woogie* (Rembert 2016 p.192) and the unfinished *Victory Boogie-Woogie* (ibid. p.195). Mondrian moved away from larger coloured planes and black lines, to coloured lines of many smaller planes, using the up tempo, syncopated rhythms and colliding melody lines of boogie-woogie music, along with the nonstop function of New York City, as a new influence (Sidelnikova 2021).

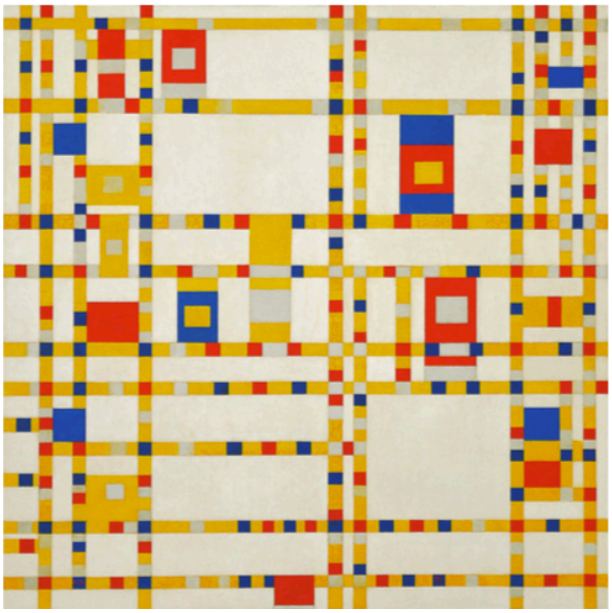

Figure 14: Broadway Boogie-Woogie, Mondrian 1942-43 (Rembert 2016 p.192)

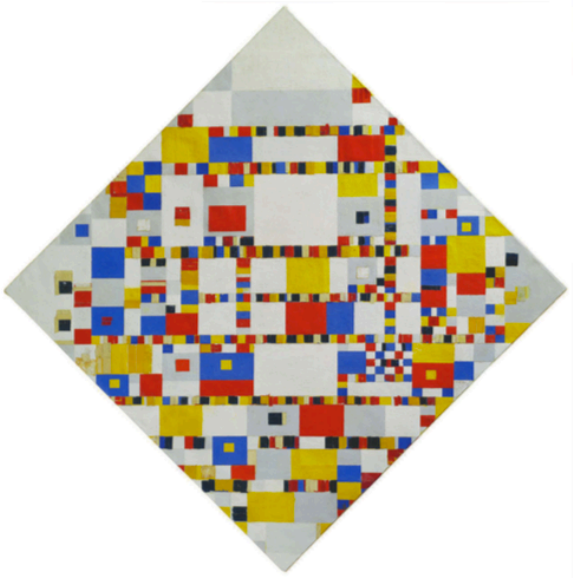

Figure 15: Victory Boogie-Woogie, Mondrian 1942-44 (Rembert 2016 p.195)

The prepared recordings are imported to the edit timeline with a subtractive approach used to delete segments from the waveforms of the six frequency bands, excising samples, as opposed to the previous adding. The subtractions, or compositional silences, become smaller and lessen until each band eventually becomes whole again and the room is again sonically reassembled in an altered state of separate, equal frequency bands. The extremities of sub and upper high frequencies are of equal level to the core high mid frequencies most prominent in the original room tone; an artificial sonic equality is achieved across the frequency spectrum and acoustic properties not previously heard in the room tone recording, such as low frequency rumbles, are made audible.

Figure 16: Rapidity Pro Tools edit.

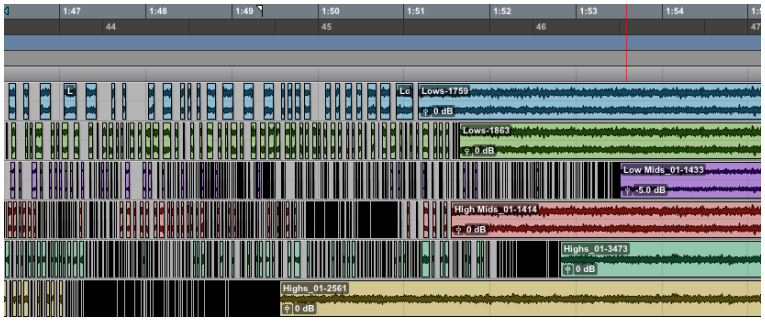

Figure 17: Rapidity Pro Tools edit details.

Walking Around an Empty House. (3:09)

Here the approach differs; longer room tone samples of the different rooms in the house are used and repeated. The composition is a sonic walk around an empty house. All sonic evidence of what makes up a home is removed - as part of the moving process - with the house peeled back to the fundamental sonic substructure. The compositional intention is to sonically interpret walking through the empty house from room to room without being there, no footsteps are heard, only the rooms. Along with my own concepts on room tone, the piece is also directly influenced by Blesser's aural architecture (Blesser & Salter 2006). The notion of being able to record the aural architecture of a room is explored in detail by simulating walking around an empty and near silent house. The fundamental question of the research is investigated: is it possible to record the sonic personalities of different rooms without inflicting resonance, and use this recorded material as the basis for composition? The difference can be heard on location but can it be presented in recording and composition?

Room Tone Recording.

The room tone recording process is similar to *Gradualism* and *Rapidity*. It is the same empty house but here all four rooms are recorded and used. Each room has a high ceiling, wooden floor, and the four rooms only vary in width, decreasing the difference between each room tone and increasing the challenge of recording the individual sonic illumination, or personality, specific to each room. Listening on location, the difference between these rooms is heard but their similarities

present a challenge in defining the four spaces in recording and composition. Again, a room tone of each of the rooms in the house is recorded late on a still night, these recordings do not claim to be especially near-silent and they do contain distant, subtle external rumbles of anthrophony that illuminate the room. But they do represent the sonic substructure of each room in a state of placidity and show each space to be rich in fundamental sonic material. Each room tone is prepared with the same noise reduction approaches used in *Gradualism* and *Rapidity*. System noise is minimised without effecting the recorded environment.

Figure 18: room 1

Figure 19: room 2

Figure 20: room 3

Figure 21: room 4

Composition.

A four second sample is taken of the quietest section of each room tone recording. There are no specific primary sounds such as passing cars, simply the culmination of distant rumbles that illuminate the empty rooms.

Each room tone is finely equalised to accentuate its individual acoustic properties; given the rooms are sonically similar, the sonic personality of the rooms needed to be highlighted for composition. A gentle rumble or other frequency is identified in the sample and then gently accentuated to emphasise any audible differences between the rooms. Equalisation is minimal to avoid drastically altering the original room tone and to only lightly emphasise the already present details of the room. The amplitude of all room tone recordings is greatly increased to make these details audible, with gentle compression used to dynamically flatten them. There are no fridges or other drones from electronic appliances and no immediate traffic sounds.

Composition is largely through improvisation using the real time performance software AudioMulch (Bencina 2021). The four room tone samples are played from four file players and four loop players triggered through a sample pad. The study opens with the four rooms played in isolation. Samples are then repeated and layered, allowing the differences in the rooms to be heard through their opposition and combinations, placing two rooms next to each other of similar characteristics highlights the subtle differences. Pierre Schaeffer's idea of repetition to give a sonic object musicality is followed again, as well as the mechanical repetition of Asmus's *What Where*, as the listener is taken from room to room at a gradually increasing and overlapping pace.

Conclusion.

This first chapter marked the beginning of the progression towards silence and laid the foundations for the field recording and compositional methods used throughout this research. In recording, the approach of excluding all primary

sound is first explored to record the sonic substructure of a room then a house. In composition, concepts and methods in reduction and repetition influenced by Piet Mondrian, Walter Asmus, Pierre Schaeffer, and Sachiko Matsubara are established and used throughout the research.

The research question here is also a foundation question of the research project, this being:

- Is it possible to record rooms in a state of placidity then use the resulting room tone recordings as sonic objects for composition?

These compositions became studies in reduction that explore room tone recording and the sound of an empty house. It was a challenging task to record such quiet material and to compose using such limitations. It was found that the recording target, or sonic personality, of a room is the low-level underlying sonic substructure made up of the acoustic properties illuminated by the external soundscape. No matter how quiet, sound is always present and will enter, during recording in this particular house, it was an inevitable distant din of anthrophony that entered. This sonic substructure was shown to be challenging to record in detail given its low-level signal and the self-noise of the recording system. The audible difference between the largest and smallest room was minimal.

The compositional concept of taking a room apart and putting it back together in a new state was difficult in working with recordings of such low-level sound and using only basic sound processing. To create progression and movement with such limitations within a strict concept is challenging; while I view these pieces as musical compositions, I feel they are very much studies of an empty room and room-tone recording. To emulate walking around an empty house by capturing the different sonic characteristics of each room in recording, then to present these differences in composition was also challenging. The similarities of the rooms made the task problematic, in order to hear enough of the sonic substructure of each, room-tone equalisation was needed to accentuate the

different characteristics, yet to stay true to the original recording only minimal equalisation was allowed. To execute this composition to the level of quietude and detail originally envisaged, further examination using microphones of less self-noise and varied directionalities is needed. The notion of working with near-silent rooms was shown to be difficult and demonstrates the need for sound to trigger acoustic properties or sonically illuminate the space for it to be heard, just as light is needed to see an object. However, this chapter demonstrates there is an abundance of material ripe for composition at these low levels.

Chapter 2. Covid-19 – peeling back anthrophony in the Sydney CBD via the pandemic lockdown.

Introduction.

Here the research moves to exterior locations and progresses from a purely creative pursuit, to one that also documents and investigates exterior soundscapes through a progression towards silence. The intention is to take the same approach to room-tone recording outside to record the 'room tone' of exterior locations, removing as much primary sound as possible to reveal only the inevitable fundamental sounds. The sound recordings are not only material for composition but now take on a larger role as unique objects that document an event or place and a progression to silence. In this chapter, the soundscape of the city of Sydney is peeled back through the Covid-19 pandemic lockdown revealing the sonic substructure of the city and demonstrating the removal of primary sound.

With the minimisation of human movement caused by the Covid-19 pandemic lockdown, during March and April 2020 the Sydney Central Business District (CBD) was forced into a previously unheard state of quietude. With a dense layer of anthrophony removed, unique opportunities were presented within this research to add another step in the progression to near silence, peel back the sound layers of a city, and listen below the usual primary sounds to explore the sonic substructure through sound recording and composition. Key questions examined were:

- What are the effects of reduced human presence on the city soundscape?
- What can be heard if we peel back primary anthrophony to the fundamental sonic substructure of the city soundscape?

The submitted creative practice materials are:

- 2.1 The Sydney CBD Covid-19 sound recordings
- Two compositions based on the sound recordings:
  2.2 *Reinterpretation of UTS Student Services Centre (3:35)*
  2.3 *Reinterpretation of the Sydney CBD Covid-19 Soundscape (5:24)*

The aim was to document and investigate the soundscape of Sydney's CBD altered by the Covid-19 lockdown. However, this does not aim to be a completed and detailed soundscape research such as that by Daniel Steele and Catherine Guastavino, 'Quieted City Sounds during the Covid-19 Pandemic in Montreal' (Steele & Guastavino 2021), but it sits within my own approach of peeling back sound to listen below common, primary sounds. Location listening and sound recording involved gathering 15 to 30-minute recordings of selected locations in the Sydney CBD using a small, portable omni AB stereo pair recording system. A bicycle was used as transport to discretely record locations during lockdown restrictions, and at times as a microphone stand with the handlebars used as a stereo bar for the AB recording technique. Each recording location was documented photographically to allow for the possibility of future comparison recordings in exact locations once the city returns to full function. The results are summarised in two compositions based on findings from the field recording practice; approaches to sound processing and composition are governed by strict rules. The following discusses other approaches to Covid-19 soundscape research, my own sound recording practice, and the resulting compositions that summarise and interpret the findings of the recording practice.

Research Contextualisation – Covid-19 city soundscape research

Gadi, the indigenous Gadigal peoples name for Sydney Cove and the surrounding area (Hinkson 2001), was once a natural soundscape free of mechanised anthrophony dominated by birdcalls, insects, eucalyptus trees moving in the wind, running creeks, and water lapping at the shore line (Park 1973). However, in its current built form as a usually bustling city, Sydney was reduced to a

unique, unheard state of quietude during Covid-19 lockdowns. As evident through the recording practice here and results from other soundscape research outlined below, the strict limitations placed on human movement to control the spread of the virus removed layers of anthrophony from the city soundscape and revealed others. In Sydney, foot traffic was reduced to the sounds of a smattering of people chatting and walking largely empty streets and iconic locations, road traffic was minimised predominantly to base levels of public transport and food delivery bicycles, birdcall was heard in greater detail, the geophony of wind blowing leaves through empty streets was clear, and the mechanical drone emitting from buildings was revealed. The soundscape was peeled back, usual primary sounds diminished, other details heard, and the acoustics of the city uniquely illuminated by only the fundamental sounds that had become central. Jonty Semper's *Kenotaphion* (Semper 2001) is a collection of Remembrance and Armistice Day recordings that capture the yearly two-minute public silences recorded at The Cenotaph in Whitehall from the years 1929 – 2000 (Kenotaphion n.d.) In the recordings a repeated distinct silence falls over White Chapel each year and is captured using different, and increasingly higher quality recording technology (Kennedy 2001). The affect of the two-minute silences on the soundscape is clear, it is a short window of quietude. The Covid-19 lockdown recordings in this research capture a further, much more extreme quietude with an entire city shut down for a long period.

Similarly altered soundscapes in other cities were observed with the resulting quietude of the Covid-19 pandemic bringing with it both positive and negative representations. There was the sudden relief from excessive city noise and the ability to hear other details such as bird song, but the quietude also signified disaster and grief. In Amsterdam, Dutch sound recordist Marcel Maas offered the positive aspect of the Covid-19 city soundscape, "it is like 1965 in my neighbourhood again: many children playing, few cars, hardly any airplanes" (Dallinga 2020). While Professor Karin Bijsterveld of Maastricht University points out the negative, "for people who are now unemployed, for example, the silence can be doubly oppressive: it stands not only for illness, but also for loss of income, for the threat that your way of life is endangered." (ibid.). Both

demonstrate diverse interpretations of silences during Covid-19 depending on the impacts and observations of the individual or community.

The intrigue of cities in lockdown was first presented through photography and news footage, as well as short films with sound recorded to camera to create a basic sound design used to enhance a deserted, almost post-apocalyptic feel. *Sounds of a City* directed by Dayne Hudson (*Sounds of a City* 2020) is one example, an edit of selected images of an empty Sydney CBD accompanied by on camera sound. It is not a detailed documentation or study of the soundscape but it is a visual montage that summarises the city during lockdown, the recording and basic sound design help promote the focus of the visual intrigue and drama of the sudden desertion. Initially there was a lack of soundscape research represented. Stuart Fowkes, project manager of *Sounds from the Global Covid-19 Lockdown* (Cities and Memories 2020), referred to the prevalence of visual documentation and the lack of sonic documentation: "There are lots of amazing photo galleries of abandoned cities and great video testimonies but there hasn't been a huge amount focusing on the way that the world's sounds have been shifting" (Bakare 2020). It was this early lack of inquiry that was one of the focus areas in my own research; that is, to capture a historical sonic documentation of Sydney's city soundscape during lockdown.

However, accurate sonic documentation of cities in lockdown did begin to emerge through participatory online projects. The above mentioned *Sounds from the Global Covid-19 Lockdown* (Cities and Memories 2020), a global, online collection of field recordings made during lockdown, included sound recordings accompanied by written descriptions captured within and outside of cities. It documented all aspects of lockdown life from: rural recordings free of anthrophony; to interior soundscapes of isolation in the home; music played to empty streets; the ritual cheers for health care workers; and cities recorded in relative silence (Cities and Memories 2020). One recording captured in Paris at Sacré-Cœur basilica contributed by Théo Serror addresses the disappearance of primary sound and the din of distant traffic and buildings:

> There only remained what's probably the closest one can get to Paris's breath. Heard from one of Paris's highest position. A deep, low and wide rumble, arising from its persistent traffic despite the lockdown and the countless air vents of its buildings and shops. (Cities and Memories 2020)

The project provided wide ranging aural snapshots from around the world using different recording approaches of varying sound quality, whereas the *Silent Cities* (Challeat et al. 2020) project that also saw a call for global participation to record and document altered urban activity used a strict uniformed approach in recording equipment and settings to capture standardised data. Audio Moth (Open Acoustic Devices 2020) recorders were used with one-minute, mono recordings captured at ten-minute intervals (Challeat et al. 2020) with data collection prioritised over sound quality. Their objectives were:

1. To study in "ordinary spaces" the ecoacoustic diversity usually masked by anthropogenic noise.
2. To study the relationship between biophony and anthrophony within different levels of economic activity, as the economic activity of a territory will slowly be restored.
3. To finely characterise the relationship linking the anthropogenic noise to the level of stable economic activity of a territory. (Challeat et al. 2020)

While this provided standardised sound data to unmask hidden sounds, and observe human activity in relation to economic activity, sound quality was not prioritised, nor were the recordings captured skilfully to accurately investigate the soundscape.

An example of a city recorded during lockdown in detail and high quality can be found in the work of Arnoud Traa, a Dutch sound designer and recordist in Amsterdam. Traa documented Amsterdam in lockdown without attempting to appeal to the drama of desertion, but as a sonic investigation of the location (Traa 2020a). Traa also presented comparisons of the soundscape using earlier work. One example by the Oude Kerk (Old Church), the oldest building and parish in Amsterdam (City of Amsterdam 2021), presents a recording from the 3rd of September 2015 recorded as part of a previous collaboration, while the

other is from the 3rd of April 2020 during lockdown (Traa 2020b). The comparison is clear and stark with a much diminished soundscape during Covid-19; the busy streets filled with tourists and the sounds of luggage wheels on cobble stones are replaced by a smattering of locals exercising or out for essential needs. Further examples of Traa's recordings and comparisons can be found with accompanying notes on his Soundcloud page (Traa 2020c). Traa describes a meeting with a resident of the Red Light District (RLD) that not only describes a change in the soundscape but also the beneficial effects it had on some locals:

> We bumped into a RLD resident, a young man living on 'the golden road' or 'strip' of the RLD in a 2nd-floor apartment. He was THRILLED with the abundance of silence and lack of stag parties, he told us. Normally he can't sleep whole nights. He can't find another house (there's a housing crisis in Amsterdam) and moving out of the city was never his idea. Now however he says: I'm reconsidering, this quiet is so good for me, I might be better off outside the city. (Traa 2020a)

The quietude brought on by lockdowns and the pause on tourism began discussion among Amsterdam residents as being positive changes that could be maintained. To take a step back from the previously encouraged excessive tourism in areas such as the Red Light District where "noise is permanent, and nuisance a given" (Snijders 2020) and allow Amsterdam to return to a quieter state "reminiscent of the 70/80s" (ibid.). As Snijders says "With tourism down and out, many are hoping things will be different after the current crisis" (ibid.). The lockdown uncovered new possibilities for quality of city life with some of these influenced by the altered soundscape. As Maas hoped, "If we learn to revalue silence, we will all have something positive about this crisis" (Dallinga 2020).

A further example of extensive Covid-19 city soundscape research was reported in *The New York Times* (Bui & Badger 2020) summarising research from New York University. The SONYC (Sounds of New York City) project (New York University 2020) was established in response to growing noise complaints in New York City where "it has been estimated that 9 out of 10 adults in New York

City (NYC) are exposed to excessive noise levels" (ibid.). The project saw acoustic sensors containing a microphone and Wi-Fi transmitter placed around the city used in conjunction with machine learning technology to automatically identify noise sources and accurately sound map urban environments to enable "city agencies to take effective, information-driven action for noise mitigation" (New York University 2020). This long running research captured areas of the New York City soundscape both previous to and during the Covid-19 lockdowns with ample and exact data gathered from the stationary sensors to provide comparisons. The quality of the recording is good but sound recording approach and execution is again not the highest priority. But like Traa's comparisons, the difference is stark and further supported with A-weighted sound pressure level readings. Data shown in one example, a sound recording with decibel information taken from corner of Lafayette and East Fourth Street in New York City (Bui & Badger 2020), demonstrates a clear difference in the volume of the soundscape, the movement and chatter of people, and traffic is replaced by building drones and bird call: "the city no longer sounds the same. And that realization is as jarring as the sight of empty streets" (Bui & Badger 2020). Juan Pablo Bello of SONYC summarises this particular pandemic quietude as not the positive outcome he hoped for:

> to me, it's the sound of the city aching … It's not a healthy sound in my mind. Even though I've been hoping for quiet in many ways for all these years thinking about noise, being obsessed with noise – somehow this is not quite what I was hoping for. (Bui & Badger 2020)

In *The Monthly,* Nicola Redhouse provides a summary of international work and projects established during lockdowns, along with the following that summarize common themes heard in Covid-19 city soundscapes:

> David Kamp, a Berlin-based composer … "It feels like the constant curtain of traffic sound ... has been pulled away a bit." … In Brussels, where a lockdown had been underway for close to a week, Randy Ali, a researcher in acoustics and signal processing, recalled a short walk from his central apartment. Usually met with "lively shops and cafes filled with tourists and locals", he encountered a "deafening silence ... It almost felt like ... noise-cancelling headphones." … From a 240-acre vineyard just to the north-east of Sonoma, California, under a flight path … Bernie Krause noted: "Very few commercial jets inbound from the

> north and Europe ... Not a single private plane for several days now. None of the usual helicopters flying over our valley." In their place, "anthropophonic textures rarely heard". (Redhouse 2020)

People were inside, anthrophony minimised, nature was heard, and other sounds revealed in greater detail. The general volume of city soundscapes was diminished through the absence of people and primary anthrophony, making for a very rare and normally impossible altering of the soundscape that carried with it both positive and negative connotations. The reduced soundscape in part demonstrated R. Murray Schafer's notion of the soundscape as a composition (Schafer 1977), or as written in the *New York Times*:

> Mark Cartwright, one of the N.Y.U. researchers, suggested that their microphones were capturing something more hopeful: the baseline sound of the city, stripped of all the idling engines, the jackhammers, the honking, the stereos, the chatter, the arguments, the commerce. We've never been able to listen to this baseline before now, Mr. Cartwright said, we can begin to ask what we might want the city to sound like on top of it. (Bui & Badger 2020)

Sydney CBD Covid-19 Sound Recordings.

All sound recordings are submitted under:

2.1 Sydney CBD Covid-19 location sound recordings

All sound recordings have been submitted unedited to demonstrate the length of uninterrupted quietude. For a detailed analysis of the recording process and results see Appendix item 1: Sydney CBD Covid-19 Location Sound Recordings.

The Covid-19 lockdowns presented the opportunity to further demonstrate through sound recording the notion of peeling back sound layers, on this occasion in the city and through a pandemic. Iconic sites usually teeming with people and sound were chosen, as were usually busy streets nearly emptied.

To gather standardised data, the same stereo recording system was used throughout with the input gain only lowered when recording in, for example,

Central station tunnel or next to passing trams to accommodate the low frequency rumbles. The portable recording system comprised of two Sanken COS11 microphones and a Lectrosonics SPDR recorder.

Figure 22: Lectrosonics SPDR recorder and Sanken COS11 microphones

The city was mainly recorded during what are usually busier daylight hours for the benefit of future comparisons to highlight the contrast in sound levels. All recordings are long form to capture a significant amount of largely uninterrupted quietude at each location that reflects how quiet the city was. Similarly to the SONYC project (New York University 2020), A–weighted SPL readings were gathered for each location with only the lower average readings documented to focus on the diminished din and sonic substructure as opposed to individual sounds. Given wind interference and low frequency rumbles of passing trams or busses, A–weighting was used to obtain readings not overly influenced by these factors.

File	Recording Location	Time	Date	SPL A–weighted (lowest average)
2.1.1	Opera Bar	16:50	29/03/20	56dB
2.1.2	Opera House promenade	08:47	13/04/20	53dB
2.1.3	Circular Quay, wharf 4 & 5	09:30	13/04/20	59dB
2.1.4	The Rocks, MCA	10:07	13/04/20	55dB
2.1.5	The Rocks, Sargent Row	10:44	13/04/20	52dB
2.1.6	Martin Place	17:50	29/03/20	65dB
2.1.7	Martin Place, Elizabeth St	15:21	05/04/20	63dB
2.1.8	Martin Place, George St	17:02	05/04/20	60dB
2.1.9	NSW Parliament House	15:45	05/04/20	53dB
2.1.10	Hyde Park Barracks	11:39	13/04/20	55dB
2.1.11	Pitt St Mall	18:24	29/03/20	56dB
2.1.12	Dymocks Building	17:33	05/04/20	60dB
2.1.13	QVB tram stop	11:14	13/04/20	59dB
2.1.14	Town Hall	18:22	05/04/20	57dB
2.1.15	China Town	14:26	04/04/20	54dB
2.1.16	UTS Student Centre 1	14:02	10/04/20	33dB
2.1.16A	UTS Student Centre 2	13:51	12/04/20	36dB
2.1.17	UTS Goods Line	14:56	10/04/20	57dB
2.1.18	UTS The Green	13:56	12/04/20	52dB
2.1.19	UTS Building 2	14:22	12/04/20	42dB
2.120	Central Station tunnel 1	13:59	04/04/20	52dB
2.1.20A	Central Station tunnel 2	15:19	12/04/20	53dB
2.1.21	Railway Square	14:59	12/04/20	66dB
2.1.22	Chalmers St	15:45	12/04/20	60dB
2.1.23	Hyde Park	11:39	13/04/20	53dB
2.1.24	Enmore Park Llewellyn St	12:40	13/04/20	49dB

Figure 23: recording locations, time, date and lowest average SPL readings.

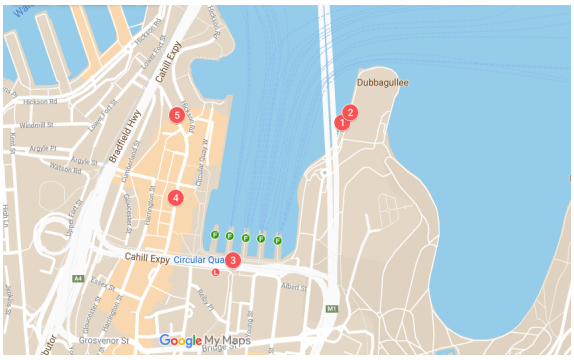

Figure 24: Circular Quay, locations 1 - 5 (*Circular Quay Sydney* 2021)

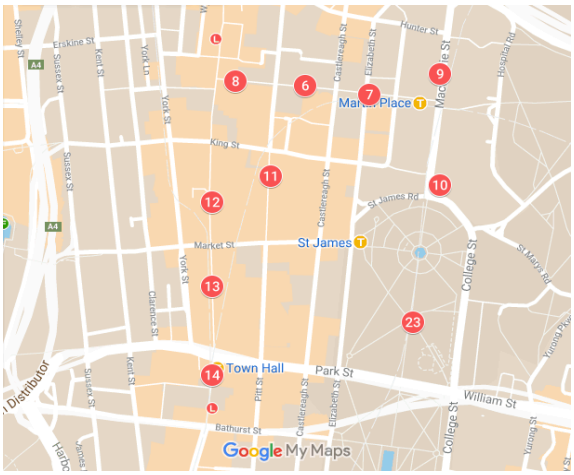

Figure 25: Sydney CBD, locations 6 - 14 and 23 (*St James Station Sydney* 2021)

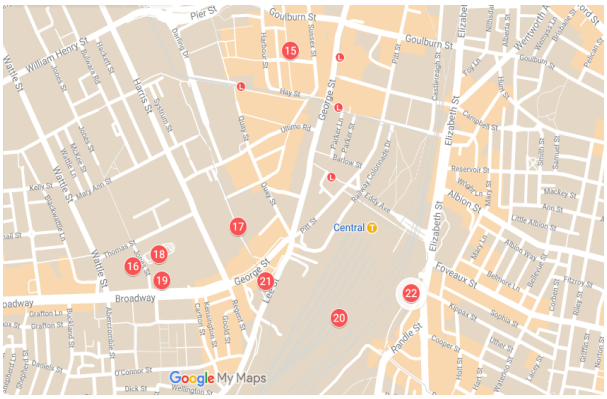

Figure 26: UTS and Central locations 15 – 22 (*Railway Square Sydney* 2021)

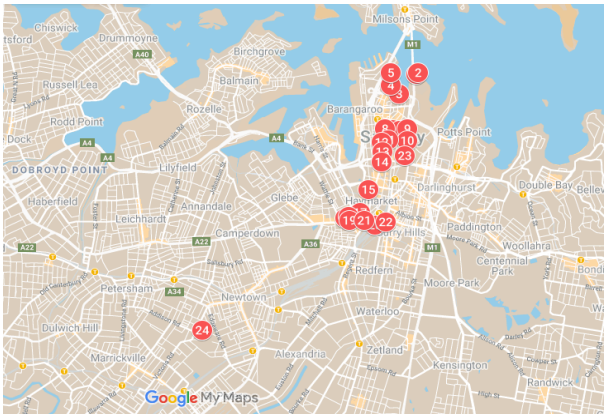

Figure 27: location 24 at Enmore Park and CBD locations (*Sydney* 2021)

The recording process sonically documented a unique, historical event and is a summary of the Sydney CBD soundscape during the 2020 Covid-19 lockdown. The recordings capture the removal of primary anthrophony - or the unique possibility to hear the city without people - an unexpected additional step within this research. The sonic substructure of building drone was revealed and dominated, along with the fundamental geophony of wind blowing autumn leaves, and water lapping at Sydney Harbour shore, sounds usually masked by primary anthrophony. The recordings capture the quietude resulting from the shutdown of tourism, hospitality, retail, education, entertainment, and other employment.

Compositions.

The following studies are submitted with this research:

2.2 *Reinterpretation of UTS Building 10* (5:35)
2.3 *Reinterpretation of the Covid-19 Sydney CBD soundscape* (3:38)

The compositions explore, summarise and reinterpret findings of the field recordings. All recordings are examined in detail using equalisation and noise reduction while preparing samples for composition. As found in the recording process, with the minimisation of human presence, foreground sound was removed and background sound made prominent, allowing hidden sounds to emerge and dominate, including: the anthrophony of building drone or expansion, the geophony of wind blowing autumn leaves or the sea lapping at the harbour shore next to Circular Quay station. These fundamental sounds were heard in this new detail only through the removal of primary anthrophony.

Composition focuses on these revealed sounds and reinterprets the selected soundscapes. First is the Student Services Centre in Building 10 at the University of Technology Sydney, a usually busy public interior emptied by lockdown. Second, is an interpretation of walking through the Sydney CBD during lockdown. Key sounds in the recordings from each location are identified and

sampled. A theme of using samples, loops, and drones for composition was seen as the best approach. Loops of samples that reinterpret building drones, or capture details of city geophony are used throughout. The approach is minimal with a strict set of rules for composition:

1. Only recordings captured during lockdown in the Sydney CBD can be used.
2. Samples must not contain any obvious primary anthrophony or biophony; all cars, pedestrian crossing signals, birdcalls etc. are avoided.
3. The only parameters allowed for sound manipulation and composition are volume, equalisation, and the length and placement of samples and loops.

Equalisation is used to focus on and isolate low frequency aspects of building drone, or focus on the high frequencies in the sounds of a creaking expanding building, leaves blowing along the ground, or water in the harbour. In doing so these sounds are emphasised and artificially brought to the foreground, reinterpreting the soundscape based on these details revealed during field recording.

As in the previous compositions based on interiors, the repetition and layering of looped samples further highlight the sounds revealed. Approaches to the use of repetition again follow Pierre Schaeffer's two preliminary steps:

> *Distinguishing* an element (hearing it in itself, for its texture, matter, colour.)
> *Repeating* it. Repeat the same sound fragment twice: there is no longer event, but music. (Schaeffer 2012)

The editing for each piece at times is intentionally clumsy, it is often fast and improvised to locate ideas in the progression or combination of samples. Some of the resulting hard cuts or stark placement of samples assist to emphasise subtler differences between building drone samples of similar sound matter through the abrupt contrasts. At other times fades are used to blend and form new timbres.

The subtleties within these individual samples or combined drones are emphasised through increasing their volume and repetition.

The building drone is often over represented in the mix to recreate an exaggerated version of these fundamental layers in composition. They combine and harmonize, at times they create subtle phasing, at others, two to three timbres combine forming an interpretation of how building drones combined on location to create the fundamental city drone. Specifically in, *Reinterpretation of the Covid-19 Sydney CBD soundscape* this phenomenon is inferred through combining different location recordings of singular and multiple drones, for instance, the singular drone of the Goods Line at UTS and the multiple drones at Pitt Street Mall.

Looped samples are also used to compose with newly revealed delicate details of geophony including leaves blowing in the wind and waves lapping against the shore. The occurrence of such brief events is reinterpreted through repetition of short or long loops that exaggerate their presence or movement, while also bringing them further into a musical context by using these as the material for composition. Details within these sounds are captured at varying lengths and emphasised through the repetition of small sound fragments that capture a very small impact sound and present it as short bursts, or one to two second loops of a brief event in the leaves or waves. Key elements of the soundscape are sampled from the recording and repeated to draw focus.

Two works, Francisco Lopez's *Buildings [New York]* (Lopez 2001) and Stephen Vitiello's installation *World Trade Centre Recordings: Winds After Hurricane Floyd* (Vitiello 1999/2000), are precursors to the two compositions below and examples of a sonic investigation into the inner sounds of large buildings. In listening to Lopez's work based on buildings in Manhattan and Brooklyn, sounds are specifically targeted and isolated by recording these in detail within the building and out of business hours. The isolated building sounds are presented as unprocessed sound matter as they fade into each other, never repeating throughout the hour-long composition (Lopez 2001). In further detail, Vitiello's

World Trade Centre Recordings: Winds After Hurricane Floyd (Vitiello 1999/2000), uses contact microphones attached to windows on the 91st floor of the World Trade Centre to capture and present the hidden sounds of the structure moving and creaking in the winds after Hurricane Floyd (Vitiello 1999/2000). Both works specifically target the sounds of buildings and present these in great detail. The approach used in this research differs with the recordings gathered not intended to be of building sounds explicitly, but of the surrounding soundscape. The possibility to record building drones in detail at street level was only revealed by the pandemic lockdown and altered soundscape. The revealed sounds of buildings resonating in the city are recorded, not sounds found within buildings.

The approach to composition also differs to Lopez's of "non-processed, not mixed environmental sound matter" (Lopez 2001), and Vitiello's literal representation of the vibrations captured through the building. In the studies here, samples taken from the recordings capture a specific sound or event, they are equalized to focus on desired frequencies, and composed with in detail to emphasize, summarize and form an artificial, exaggerated interpretation of the selected soundscape.

Reinterpretation of UTS Building 10.

The recording of the UTS Student Services Centre this composition is based on was captured early during Sydney's 2020 lockdown; the quietude summarises the effect of the Covid-19 pandemic on higher education. Usually a hub of activity, the building is reduced to the fundamental sonic substructure of building drone, electronic whines of lights, and the sounds of creaking and cracking caused by the sun coming out and heating the building, a sound that would usually be masked by the sounds of general campus activity. Vitiello's contact microphone recordings of the World Trade Centre demonstrate the creaking sounds created by wind blowing the massive structure, here it is the sun that gently plays the building with the resulting sounds echoing through the space, creating a combination of anthrophony (the presence of the building) and

geophony (the heat of the sun). It is these details of building drone and expanding that are focused on in composition.

This reinterpretation explores the sound of the sun warming, or playing, the building underscored by the inevitable drones of the building. Isolated building drone is sampled between any sound of external traffic and internal sounds of the building. Samples are increased in amplitude then equalised to focus on traits of low frequency rumbles and other frequencies resonating through the large space. Similarly to the previous Interiors compositions based on room tone, the drone is separated into samples of different frequency bands for composition. The approach here is not so methodical and dissecting; it is an improvised exploration using equalisation to focus on elements and gather samples. The resulting samples form the basis for improvisation using AudioMulch (AudioMulch 2021), with further editing used to investigate, and reinterpret this fundamental drone. Through the looped repetition rhythms emerge, samples are layered with new layers modifying the previous as they harmonize. Drones alternate as the fundamental layer, or fade in and out of each other, creating new timbres.

The cracking sounds of the structure expanding are also sampled then isolated through equalisation and noise reduction to remove low frequency rumbles and electronic whines. Some samples are of the resulting reverb only triggered by the cracks. Samples are again looped and layered in AudioMulch-based improvisations that are refined in the edit, these are then combined with the building drones and composed as one. Samples may be as short as a single crack, or a brief event of three to four cracks in a row. Samples are repeated but not looped in a tight repetition; they are placed and gradually increased to exaggerate the gradual heating and cracking of the building heard in the original recording. This increase is further enhanced with increasing looped layers of cracking sounds equalised to focus on the higher frequencies.

As in the previous interiors compositions, all samples are placed in the stereo spectrum with no movement, any movement occurs during recording as sounds

pass the stereo image. It is seen as unnecessary to attempt to spatially recreate locations or experiment with the stereo spectrum, the aim is to focus on the content and reinterpret the fundamentals of the selected soundscape without the dramatics of panning moves. Panning is used to create width and separation between textures, any low frequency sounds are panned towards the centre, higher frequencies are panned equally across the spectrum.

Reinterpretation of the Covid-19 Sydney CBD soundscape.

Again, the composition summarises the findings of recording practice, here it is a reinterpretation of a walk through the Sydney CBD during lockdown from the University of Technology Sydney to Circular Quay. As the sound recordings show, primary anthrophony of human movement was drastically minimised and details of building drone and the geophony of leaves and water were revealed. These fundamental aspects of the soundscape are focused on in composition.

Looped samples represent the numerous building drones but are also used to accentuate details in the geophony heard with the absence of primary anthrophony. The building drones used are from selected areas within the Sydney CBD but not composed strictly in order of progression from the South to North end of George St. The piece begins within building drone recorded at the Goods Line at UTS, then moves to China Town with the diminished building drone and geophony of wind blowing Autumn leaves that rattle in the branches or skim along the ground. The sounds of leaves used here composition are taken from the China Town and Martin Place at Elizabeth St recordings. Leaves blowing across the ground and small individual rustles are sampled and looped. These are mixed into longer looped selections of the recordings in which these sounds are most dominant. Short artificial bursts of looped leaves are placed on top and develop in amongst those captured on location, subtly at first and then becoming prominent. A sound that was previously largely overpowered by primary anthrophony is captured and looped to accentuate its details and investigate the revealed details of leaves rustling.

The composition moves from China Town and continues along the closed corridor of buildings on George St until we are at Martin Place where building drone is all around and funnelled within George St. As the piece moves out of the prominent drones to Circular Quay, extreme noise suppression at a frequency of 368Hz is gradually faded in on the building drones, creating noise reduction artefacts that break up and fade these drones as the reduction increases. At Circular Quay, the absence of tourists and harbour traffic allows the details of water lapping against the harbour wall outside of Circular Quay station to be heard in much greater detail, allowing for the sounds of water to now be focused on and composed with. The compositional approach is similar to leaves but now takes some influence from Hugh Le Cain's *Dripsody* (1955) in which a single drop of water is the basis for composition with the pitch manipulated through playback speed (Young 2008). Here, it is not the pitch-shifting, but the rhythm of a flurry of notes coming from a single event of a drop of water that is of most influence. Similarly to working with leaves, the water lapping at the harbour shore and the sound of water colliding is sampled then mixed into another layer of longer water and wave sounds. The difference in approach occurs when details in the water are identified, picked off, then looped on their occurrence within the recording as it plays, as opposed to samples and loops being placed on top of a layer then mixed in. This allows the looped details of the waves to emerge from within the recording, extending from the selected individual drip or collision of water. The use of these two different approaches to loops in composition allows alternate explorations of the recorded environment but also permits two approaches to looping. One is to capture samples to place on top of layers; the other is to capture events within the recording and loop these, providing an alternate sonic outcome. There is a progression in looping; from samples that are singularly placed and repeated over other layers (cracking of the roof), samples that are tightly and rhythmically looped over a layer of a specific event to highlight this event (leaves), to samples that are captured and looped within the original recording and extend a detail within an event (water).

As in previous composition, all samples are placed in the stereo spectrum with no movement, any movement occurs during recording as sounds pass the stereo

image. Panning is used to create width and separation between textures, any low frequency sounds are panned towards the centre, higher frequencies are panned equally across the spectrum.

The interiors compositions in chapter one use samples based on room tone and the sonic substructure of a room or house captured only by minimising all primary sound to explore the acoustic characteristics of an interior. Similarly, these Covid-19 city soundscape studies are based on the sonic substructure of the city also captured through peeling back the sound layers, but here via a pandemic. They explore the fundamental layers of each location as well as the revealed details of geophony and use this as the basis for composition.

Conclusion.

The Covid-19 pandemic provided a further possibility within this research to remove sound layers in the usually bustling CBD of Sydney. Primary sound layers were peeled back through lockdown restrictions, with the Easter holiday and lockdown combining to further remove anthrophony. The idea of what the city would sound like if everyone left was explored and the volume of the city structure itself was emphasised through a sudden absence of people. Building drones dominate the sound recordings and are shown to be the sonic substructure of the city forming a thick, all-encompassing sonic bed. It is a sound not usually heard consciously in such stark detail, hidden under the primary sound layers, but it is accepted as part of city life despite its surprisingly significant presence. The absence of primary anthrophony also allowed other details of city function to be heard clearly and singularly including pedestrian crossings, light rail, trains and buses. Its people were largely gone but the sound of the city's function remained. Other sonic details of minimal human presence such as footsteps, clothing rustle and passing conversations were all heard in the diminished soundscape. Birdcall seemed louder and the wind blowing autumnal leaves through empty streets was heard in greater detail at a number of locations. Time of day presented minimal variation in recording - the quietude bringing daytime sound levels down to those of the night. Areas of the city

soundscape resembled a country town except for the sonic presence of buildings and base-level infrastructure illuminating the acoustic properties of the city.

This Covid-19 soundscape chapter is a practice-based investigation that provides another step in peeling back sound layers within this research, but it also documents the Sydney CBD lockdown soundscape just as photographers have created a visual documentation of empty streets. At the time of submission of this thesis, I know of no other concise and standardised sonic documentation of the Sydney CBD during lockdown. However, it does not specifically aim to be a Covid-19 soundscape research, although it is positioned for future research. More information on pre Covid-19 city function and the reduced function during lockdown such as; public transport timetables, traffic volumes, reduced tourism data, and any pre Covid-19 CBD soundscape sound-level readings are areas in which more information may be gathered to further understand the affects of the shutdown on the soundscape. Further comparative data documenting the city soundscape during the 2021 Sydney lockdown would also add to this body of research. There is also of course the possibility to capture comparison recordings using the same recording system in the exact locations when the Sydney CBD returns to full function. With these factors a more detailed soundscape research may be conducted to fully understand the impact of the Covid-19 lockdowns on the Sydney soundscape. Will it return to the pre Covid-19 levels or has the Sydney CBD soundscape been permanently altered with the increase and developments in people working from home; will this possibly mark the beginnings of a quieter city?

A loop-and-drone-based approach to composition using samples from the recordings creatively summarised the findings of the recording practice and the impact of the lockdown on the soundscape. Aspects revealed through the removal of primary anthrophony were focused on, captured and used for composition to reinterpret the new soundscape. The implementation of strict rules for composition and sound processing followed the continuing theme of reduction in composition within this research, but this also allowed the recorded sounds to hold a connection to the locations and events. While the source and

sound association to the event is remembered in sampling and composition, each sound is approached as fresh sound matter for composition.

Chapter 3. Remoteness – recording the natural sonic substructure.

Introduction.

The room tone recording approach now enters the field of nature recording and is taken to remote locations. As with room tone recording in interiors, all primary sound is avoided, here sound layers are peeled back through remoteness by traveling to a desert region in northwest New South Wales Australia. To avoid the levels of urban sound environments we leave the city, to avoid the sounds of people we leave the town, to avoid the sounds of traffic we leave main roads, to avoid the sounds of animal life and flowing water we travel to a barren landscape, to avoid any wind other than a gentle breeze we aim for still weather. The anthrophony of human infrastructure and function is escaped and biophony eventually minimised in a search for the sonic substructure in the natural world. This is the recording target; it may be seen as a base level room tone of the natural soundscape. It is an example of extreme natural quietude verging on silence, a hidden, very rare, and ancient sound that precedes complex life.

The primary question asked was:

- What is the lowest sound layer of the natural soundscape?

The submitted materials are:

- 3.1 The Bourke to White Cliffs sound recordings.
- A composition based on the field recording process:
  3.2 *A Near Silent Desert Sunset with Fly.*

Research Contextualisation – previous exterior recording approaches.

Sound recordists and composers have often looked to record hidden, discreet sounds in our exterior environments for research, exploration, and to gather

materials for composition. Exploratory and creative approaches to exterior field recording are used to investigate hidden sounds we cannot commonly hear. Sound recordist Chris Watson describes his method as “putting microphones where you can't put your ears, because then you make the world come alive.” (Watson 2017). Watson uses sound recording to explore, discover and research natural environments and wildlife. *Vatnajökull* (Watson 2003) presents one example with recordings of ice flows from an Icelandic glacier captured via a hydrophone placed underneath the ice. *Cracking Viscera* (Watson 1998) features the sound of vultures feeding on a Zebra carcass recorded by placing microphones within the carcass. Both examples demonstrate a creative, exploratory approach to field recording, capturing unheard sounds that uncover and listen to geographic function and animal behaviour.

Jodie Rose and Jacob Kirkegaard use exploratory approaches to find new, hidden sound material for composition in music and installation. Rose records the sounds of bridges using contact microphones, capturing the inner voice of a bridge and presenting it through composition. Of her album *Singing Bridges Vibrations: Variations* Rose states, “the sound of the cables is the voice of the bridge, singing concrete music, the vibrations tell stories of the life and memory of the structure” (Rhizome 2002). In relation to works based on the sounds of melting ice, abandoned buildings in the town of Chernobyl, to those within the ear itself (Kirkegaard 2017) Kirkegaard posits:

> more interesting is to discover those things that are not so apparent at first sight because I think we live in such a noisy world and everything is pushed in to our face and what I think is interesting is to find the fragility or hidden layers (*Place and Sound* 2013).

This research follows this concept of looking below the obvious in exterior settings. Without using instruments that can hear within or below objects, a methodology of peeling back the soundscape through remoteness is used to focus on and record the near silent sonic substructure that sits below primary sounds, a sound we cannot commonly hear in our soundscapes often dominated by anthrophony. The background is prioritised over foreground; the focus is not

on an animal call or a waterfall, or an attempt to realistically capture a natural environment, but on the often inaudible geophony of the sonic substructure below.

The avoidance of primary sound is the intention and the recording target specific, but the recording process also embraces an approach of falsification and hyperrealism (Lopez 1998) in nature recording. Here the term nature recording refers to David Michael's definition of one "whose subject is 'nature' or 'environment'...where the composer minimizes editing with the intention of somehow representing the original sound field" (Michael 2011 p. 206). It is an "obsession with documentation and transportation of place" (ibid). If the recording target is a pristine natural sound environment, this is the singular focus, avoiding any anthrophony in recording or composition as an attempt to deliver this ideal to the listener. This does not accurately record the location and all its sounds but selects and captures the desired target. Michael observes this form of nature recording is often "panned as kitschy New Age, accused of pandering fantasy as 'reality' to a naive public, and, worse maintaining and perpetuating a picturesque, romantic view of nature" (ibid.). He continues to quote Jim Cummings from the liner notes to the album *The Dreams of Gaia*:

> Most, if not all, nature sound recordings foster the illusion of healthy ecosystems; many times even the location being recorded is severely degraded, and only a combination of boundless patience in the field, careful editing out of human noise, or overdubbing of field recordings can recreate the primal fullness. (ibid p.207)

It creates a false recreation of the soundscape based on the compositional intention and desired outcome or product, while also at times misrepresenting the reality of ecosystem degradation. Francisco Lopez sonically embraces this falsification and resulting hyperrealism in *La Selva* (Lopez 1998), a composition made up of sounds recorded in the Costa Rican rainforest La Selva. In an accompanying paper 'Environmental Sound Matter' (Lopez 1998), Lopez refers to the attempts at realism through carefully constructed nature recordings and compositions:

> Although I appreciate very much the multitude of new sound nuances and the 'spaceness' provided by these technological developments, I don't have a special interest in pursuing 'realism'. Moreover, I believe these techniques actually work through hyper-realism, since the carefully recorded, selected and edited sound environments that we can comfortably enjoy in our favourite armchair offer an enhanced listening experience. Somewhat paradoxically, it is precisely what they have of non-realistic what I find most appealing in these sound work efforts. (ibid 1998 p.3)

In discussing Lopez's concepts on realism and hyperrealism, Makis Solomos suggests "the pretense of making us (re)live a location via its sonic environment is sheer illusion, and even trickery (hyperrealism)" (Solomos 2019 p.4). Lopez is not interested in an attempt at realism and framing reality, rather he takes and explores the notion of hyperrealism:

> Lopez's nature is even more fantastical than the fantasy we hear in nature sound recordings. In his works, forests transform into transcontinental animal compositions, and thunderstorms become absolutely apocalyptic. He confronts the hyperreal of nature sound recording by embracing it and accentuating its flawed assumptions almost to caricature. (Michael 2011 p. 208)

Lopez explores and uses the flaws and falsifications. He collects sounds and is not concerned with sound association or ecological message, but on sound matter and the sonic object favouring Pierre Schaeffer's notion of reduced listening or as Lopez prefers, a "profound" listening (Lopez 1998 p.3). "While the origin of the sounds is often recognizable, the emphasis is on immersion inside the sound-in-itself" (Solomos 2019 p.1). This is also evident at a Lopez performance where the preference is to blindfold the audience for a complete immersion in sound (ibid.). The focus is on the composition of sound matter, *La Selva* does not intend to factually present the Costa Rican rain forest in composition. Lopez says himself:

> What you can listen to on this CD is not La Selva; it explicitly doesn't pretend to be so. In other words, *La Selva* (the music piece) is not a representation of La Selva (the reserve in Costa Rica). (Lopez, 1998 p.4)

This hyperrealism is an approach I take, I target and amplify the specific near silent sonic substructure and do not set out to record a natural environment in a true sense by capturing all sound as it happens. Remoteness is used to escape primary sound; then these remote locations are recorded in a manner that excludes sounds and strives to capture the sonic substructure alone. The rare event of a passing car while recording during this trip was avoided on location and if necessary edited from any composition, as are the sounds of wildlife. Bodies of water are avoided for the sound of water flowing and the animal life they attract, clusters of trees are mostly avoided for the sounds of wind through leaves and bird life. These aspects combine to isolate a specific sound following an approach of hyperrealism to recording an environment.

My work is part documentation as found in the sound recordings that do capture near silent locations and a progression to near silence. But in composition the approach is a summary and interpretation of the recorded results that follows Lopez's hyper-real approach to *La Selva* (Lopez 1998). As with the sound of an empty room, I do not break sound association entirely in composition, the remote locations and the documentation of a progression to silence is remembered, but in composition the recordings move from objects of investigation and documentation, to sound matter to suit compositional intent.

Bourke to White Cliffs – recording the sonic substructure in the Australian desert.

Locations where anthrophony and biophony could be evaded and geophony minimised to only subtle winds were needed. The area west of Bourke to Wanaaring then south to White Cliffs was selected after previous exterior field recording in remote areas within this research. It is a remote, sparsely populated region and the Bourke-Milparinka back road was correctly anticipated to contain minimal traffic. The landscape is a red dirt desert and while there is certainly wildlife and vegetation, it is minimal in the locations selected. Recording took place during the cooler, dry winter months in July 2020. The Covid-19 pandemic

may have impacted air traffic but this is not certain, however, only one plane was heard while recording over three days.

Previous recording practice in this research between Alice Springs and Uluru in the Northern Territory of Australia, and at Grasslands National Park in Saskatchewan Canada informed the location selection and recording practice. Fieldwork around Alice Springs and Uluru in February 2016 demonstrated the difficulty in escaping sound and showed locations perceived to be remote can contain constant anthrophony. This region is busy with tourism and trucks on the relatively heavily trafficked roads with times of no anthrophony short lived. Additionally, biophony is continuous during the daytime heat of summer; flies are more active with the breeding season taking place in the warmer months (Lessard & Yeates 2016). A recording of one location hears the soundscape at times verge on the desired near silence but for the constant buzzing. Therefore, it was found any future recording in the Australian desert would be carried out during the cooler winter months when insect life is less pronounced.

Figure 28: Recording location looking towards Kata Juta in the Northern Territory Australia.

A second exterior recording trip to Grasslands National Park Saskatchewan Canada was inspired by the work of sound recordist and acoustic ecologist Gordon Hempton, founder of the One Square Inch (2021) project. Hempton

classifies Grasslands National Park in Saskatchewan Canada, a largely undisturbed “native mixed-grass prairie ecosystem” (Parks Canada 2021), as one of the quietest places in North America meeting his criteria of “15 minutes of daylight without any anthropo-genic noise” (Rubinstein 2012 p.40). Hempton’s research led me to record in Grasslands National Park in June 2016. While there were long periods completely free of anthrophony, biophony was continuous along with the geophony of wind. Ground dwelling prairie dogs were the most unavoidable source of biophony and the strong winds blowing through the grasslands provided geophony. Recording here on a still day may allow the grasses to absorb sound and contribute to quietude but varying weather on this trip did not allow. However, recording in the natural quietude of Grasslands National Park was an important step to further inform recording very quiet soundscapes. Microphone capability and system noise in these quiet environments was better understood. The difficulty in capturing such a low level sound environment was demonstrated with significant system noise added during recording by increasing input signal levels. In postproduction, high playback levels used to hear details of the recorded environment increased the presence of system noise. Importantly, the similarities between system noise and sound of the wind through the grasses was also shown. All led to the further development of noise reduction approaches specific to these very quiet environments recorded and discussed below. Additionally, a better understanding was gained of what the recording target of the near silent sonic substructure actually is at this point of the progression, if all anthrophony is avoided there was still the geophony of wind below the primary sounds of wildlife.

Figure 29: recording at Grasslands National Park Saskatchewan Canada

Bourke to White Cliffs sound recordings.

Refer to the submitted sound library:

3.1 Bourke to White Cliffs Sound Recordings.

For an analysis of the recording process see appendices item 2: Bourke to White Cliffs Location Sound Recordings.

All recordings were captured in both stereo and ambisonic formats at 96kHz and 24-bit. For submission the recordings here have been edited to five minutes to focus on the key aspects. While capturing high quality recordings is important and allows a better investigation of the soundscape, the approach to recording is for investigative purposes and to gather material for composition, not intended as an attempt to realistically sonically transport the listener to the desert. These are very quiet environments at 35dB SPL and below; therefore system noise is prevalent here. There is a certain amount of listening through the recording

technology given the extreme quietude of the locations. Microphones of less noise and different directionalities would provide alternate and maybe better results in capturing finer details of the sonic substructure but such details were only revealed after the recording trip. For example, a microphone with a cardioid directionality could be useful in capturing further details of gentle winds. The stereo system is the same as used in the Sydney CBD Covid-19 recordings, consisting of a spaced omni AB pair using Sanken COS11 microphones (Sanken Microphones 2021) and a Lectrosonics SPDR recorder (Lectrosonic 2021), the use of two omni lapel microphones as a stereo pair is taken from Chris Watson (Watson 2017). The ambisonic system consisted of a Rode NT-SF microphone (Rode 2021) and a Sound Devices 788t (Sound Devices 2021) recorder. The submitted stereo recordings are seen as the most useful here. The spaced pair is more suited to my recording intentions and captured more details, specifically the gentle winds. As stated, it is an investigation of soundscapes for research and composition, not an attempt to transfer the listener to a place.

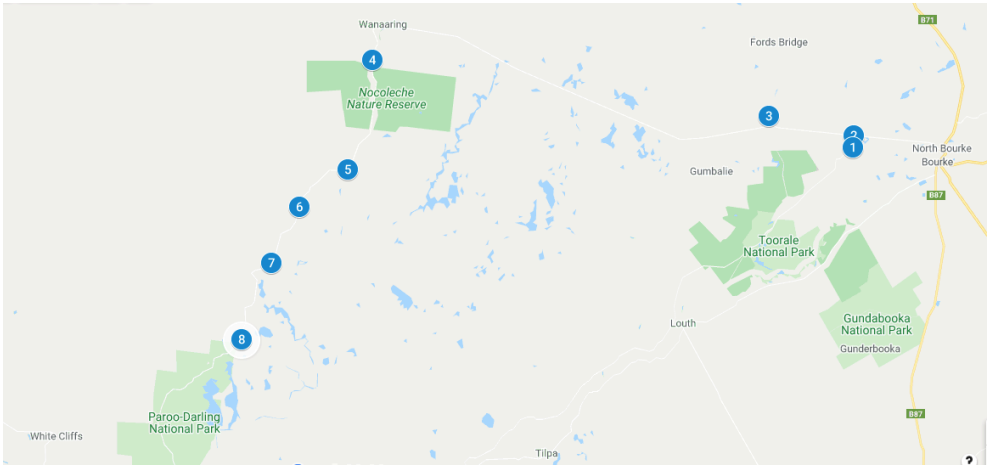

Figure 30: recording locations marked along the Bourke-Milparinka road. Recording began in Bourke, travelled west to Wanaaring, then south to White Cliffs (Bourke to White Cliffs 2021)

As the recordings progress from west of Bourke to more remote regions on the back road towards White Cliffs the soundscape diminishes to an eventual near silence. Such extreme quietude that truly borders on a sonic silence was not expected; given the findings detailed below, these areas are surely some of the quietest natural environments on Earth.

These recordings from Bourke to White Cliffs are the quietest natural places within this research. One of the quietest possible soundscapes in our exterior world was heard and recorded in this remote region on an ancient landscape. While listening on location and to the recordings later, in between the occasional distant chirping of birds only the most base level geophony of subtle winds blowing over the landscape and through the low-lying vegetation is audible. In the quietest areas even light winds cease entirely with periods of seemingly no sound. Gordon Hempton's quiet soundscape criteria used in North America of fifteen minutes of no anthrophony during daylight hours (Rubinstein 2012) was found and recorded multiple times throughout. Yet, as I have established, there is no silence in the natural world; on location the listener is left with only the sound of their presence and what is hypothesised to be distant geophony caused by gentle winds resonating over the landscape. Even if not in the immediate vicinity, it is thought surrounding winds resonate through the vast landscape creating this delicate, almost non-existent din. Comparatively, when discussing the "Voices of the Wind" (Schafer 1977 p.21) R. Murray Schafer refers to wind resonating through the landscape:

> How curious and almost supernatural it is to hear the wind in the distance without feeling it, as one does on a calm day in the Swiss Alps, where the faint, soft whistling of the wind over a glacier miles away can be heard across the intervening stillness of the valleys. (Schafer 1977 p.22)

While this desert landscape is of course very different from the Swiss Alps (with only occasional light winds at the time of recording, no glaciers, valleys, nor an abundance of plant life to blow through), the notion of wind resonating over a landscape is thought to be possible even in still weather over a flat landscape. Listening to details on location in the quietest areas and during the night, there is no other perceivable sound, but it is also not silent. In the recordings, during periods of no audible biophony or geophony, there is a presence but no distinct sonic environment captured and the recording systems are taken to the lowest limit. The threshold of recorded environment and system noise is blurred. Noise reduction techniques are used to accommodate large increases in playback

volume to listen closely for the any slight sounds during these specific silent periods, but seemingly only the sound of system noise remains.

Noise reduction approaches used on other recordings of quiet environments within this research that contain only base-level room resonance in interiors show these can combine with the system noise to the point of being indecipherable. System noise and these soundscapes are similar sounds once recorded and mould into each other. As Schafer suggests “the wind, like the sea, possesses an infinite number of vocal variations. Both are broad-band sounds and within the breadth of their frequencies other sounds maybe heard” (Schafer 1977 p.22). System noise may also be seen as a broadband sound and can have a similar effect. The threshold between the sonic environment and noise is not clear in these desert recordings with system noise bearing a resemblance to recorded wind.

The playback volume is again important. As with empty rooms, extreme increases or decreases in amplitude will change the timbre, characteristics, and sound association of a recording. A very quiet recorded room can sound like a noise composition at extreme volumes. Again, in following Chris Watson (Watson 2017), listening to these desert recordings at a low playback level that does not replicate but reflects the sound level on location gives a better representation and understanding of the soundscape.

Noise reduction decreases amplitude and the output needs to be increased to compensate and return the playback to pre-noise-reduction levels. Heavy use of noise reduction facilitates large increases in playback volume to listen within the noise floor to hear what, if any, sound is present. However, too much reduction and this approach begins to negate itself with each volume increase adding further noise. It becomes a repeating catch. Forcing a louder playback level increases system noise and therefore more noise reduction is needed. In short, playing recordings loud doesn’t necessarily allow the listener to hear more of the environment.

Importantly, heavy use of noise reduction will also begin to remove the subtle wind sound that is now known as the target sound in these recordings. Noise reduction is more often used to remove background noise to clean a primary sound such as recorded dialogue, but here the background noise is the primary sound and isolating the target is difficult, especially in the desert where the base sound is of low-level wind. In these desert recordings, noise reduction is used sparingly to ensure the sound environment is preserved and as much as possible of the location heard. I found that minimal system-noise removal, and a playback volume that is not as low, but similar to the sound level on location was best in allowing the sonic environment to be heard and understood in the recordings.

Listening on location and emulating the soundscape in postproduction also assists noise reduction approaches in regard to the sound recordings (noise reduction approaches in composition differ and are outlined below). In the quietest areas while on location there are no perceptible physical or sonic low-frequency rumbles, nor high frequency hiss or whines, the soundscape is truly near silent. Like the fresh air in these locations, the soundscape is sonically crisp and clean without the weight of primary sound. In conjunction with anechoic chamber noise prints, frequencies determined to be system noise are removed subjectively by ear using equalisation and multiband noise reduction. Reference sounds such as my speaking voice in the recording giving location details, and other sounds such as bird song, are used as a reference to determine how much noise reduction is being applied, if these reference sounds are overly affected by noise reduction artefacts or the high frequencies lost, the noise reduction is lessened in an attempt to preserve the environment recording. The use of microphones of less self-noise could capture more details of the environment, particularly wind, however with such quiet soundscapes similar issues may begin to emerge with the increases in recording gain and playback volume.

Figure 31: Waves WNS noise reduction settings for sound recordings playback. At this stage noise reduction is used sparingly to remove prominent system noise but ensure to leave the recorded soundscape untouched.

Composition.

3.2 *A Near Silent Desert Sunset with Fly* (3:30).

The same theme of reduction in composition is followed with strict rules in place, these being:

1. Only the sound recordings captured between Bourke and White Cliffs can be used in composition.
2. Samples used must not contain any anthrophony or biophony. Bird and insect call is avoided, *except one noted occasion.*
3. The only parameters allowed for sound manipulation and composition are volume, equalisation, and the length and placement of samples.

In composition, two recordings are used to summarise what is found to be the sonic substructure made up of winds, and to sonically interpret a desert sunset. Francisco Lopez's *Winds [Patagonia]* (Lopez 2007) provides a previous example of composition based on wind recordings. Christoph Cox gives a summary of the

album as “an hour-long, unedited and unprocessed recording of wind as it sweeps through the Argentine Patagonia” (Cox 2009). Cox continues on in further detail:

> It draws our attention to a host of auditory phenomena that ordinary hearing ignores or relegates to the background … the piece as a whole focuses on the very medium of sonic transport – air – and highlights the fact that sound is simply the result of pressure changes in that medium. Its subject matter – wind – is the most elemental of all phenomena and the most primeval sonic stuff. (Cox 2009)

The composition with the sound of wind in *A Near Silent Desert Sunset with Fly* is similar, however the winds used in this composition are subtle, almost non-existent. They have been exaggerated in recording and composition. The recording approach in the research is to document the sonic substructure and the result is the wind, the wind is not the initial recording target as in Lopez’s composition, it is an outcome of an investigation. While Lopez’s intention is to record and compose specifically with winds of different intensities and characteristics, my intention here is to record and compose with the lowest-level sonic substructure. Wind of this subtlety in a remote barren location is an example of the quietest sound layer in the natural world brought to the foreground and amplified through sound recording and composition. On a further level, one artist exploring wind below the extremities of human hearing is Felix Hess who captured infrasound data based on air pressure movement and translated this into the human hearing range (Richardson 2014) on his album Air Pressure Fluctuations (Hess 2001). Though, this is of course based on infrasound data outside of our hearing range capture by a sensor and is not part of the audible sonic substructure I target.

Noise reduction in composition is done subjectively by ear; it is part of the composition process becoming a sound manipulation method based on the subjective listening experience on location and my interpretation of this. It is artificial and falsification is embraced. Equalisation was used to remove excess low frequencies, with an anechoic chamber noise floor recording used as a reference. System noise is subjectively removed to interpret the crisp, clean

listening experience on location yet still retain enough of the sonic environment. An initial instance of noise reduction removes the majority of system noise, with a second to further remove these frequencies. This was used to replicate a two-stage equalisation, for example pre and post compression EQ, but with multiband noise reduction. It was found using two stages of noise reduction, one pre equalisation and one post, allowed more detail by creating less reduction artefacts. The first instance removes most system noise, the EQ lessens low frequencies from 75Hz down, a second instance of noise reduction finely lessens the higher frequency system noise.

Figure 32: first instance of Waves WNS settings for composition shows more reduction to artificially replicate my 'crisp' listening experience on location.

Figure 1 Figure 33: second instance of Waves WNS settings for composition shows further composition reduction.

In composition a hyper-real condensed version of a near silent sonic sunset in the desert is created. In some instances, sounds of the recording process are heard in the stronger wind gusts that blow against the microphones creating low-frequency rumble, these are retained as part of the process of recording wind. The quietest day recording of Location 7 is used with the night recording of location 8b, and the two are faded into each other as day to night. The final winds mark the transition to night. Playback volume is greatly increased and heavy noise reduction is used to remove system noise and artificially emphasise the almost silent soundscape. However, the level of the composition is very low in comparison to the previous compositions, this reflects the low-levels of the location, the low-level nature of the sound recording, and the compositional concept of a near silent desert sunset.

It is a composition that gradually develops as the day crosses to night. The day predominately hears winds gently gust across the flat barren landscape; in the recording they blow within and over the system noise. The sound of a lone fly passing the microphones is included to draw attention to the quietude of the desert, the fly pierces the quietude with it's sudden volume as it buzzes by the microphones demonstrating just how quiet the location was. It is also a sonic

association to daytime in the desert through a common sound that also proved difficult to avoid in the previous desert recordings within this this research. The night however is perfectly still, although a gentle sonic presence is still heard that is not system noise alone. Again, assuming we are far from all anthrophony, this continuous din is thought to be made up of only surrounding winds.

Conclusion.

This chapter saw the research progress to nature recording and remote natural locations to ask:

- What is the lowest sonic layer of the natural soundscape?

Through travelling to remote locations, the noise of the city and general anthrophony is escaped, then all biophony is removed, until there is only the delicate, base-level geophony that is found to be made up of gentle winds. Even in the quietest areas it is not silent. Once we evade all human sound by going to a quiet remote location, selecting the quietest season in regards to wildlife, and using time of day to minimise biophony and geophony, we are left with the target sound of the near-silence. Areas such as these of extreme quietude represent the ancient sonic substructure of the natural world.

Composition based on Francisco Lopez's approaches summarised the field recording outcomes. An interpretation of a near-silent desert sunset using two recordings of the quietest day and night locations presented the shifting sonic substructure of gentle winds and near-silence.

Now it is understood the sonic substructure of such quiet soundscapes is comprised of gentle winds, future research could see the same Bourke to White Cliffs recording trip using different recording systems to focus specifically on these winds. Less system noise and added wind protection would be advantageous along with microphones of lower self-noise and different directionalities to capture more detail and emphasise these gentle winds. This

would also open the possibility to explore and record the sonic substructure of different environments around the world comprising of such low-level natural sound: from deserts and grasslands, to snow-covered regions in the depths of winter.

Chapter 4. Altitude – the weather balloon recording method.

Introduction.

This is the final step in the progression of the research and marks an attempt to escape all sound through altitude. Given even in remote areas of the Australian desert there is always the fundamental geophony of wind, the weather balloon recording method is an exploratory field recording technique that investigates the notion of escaping all sound to locate and record a sonic silence in the sky. Weather balloons are used to quietly send microphones and cameras through the troposphere and into the stratosphere just beyond the Ozone Layer to altitudes of 28 – 33km, placing microphones at the edge of the sound world. The progression of peeling back sound layers has moved from: an empty room, to a house, to the Covid-19 Sydney CBD soundscape, to remote locations, and finally to the stratosphere.

The weather balloon recording method investigates:

- Exploratory sound recording and the development of a new field-recording technique using weather balloons.
- Aerial phonography – recording soundscapes from above as opposed to the usual within.
- Recording the sonic environment of the troposphere and stratosphere.
- The attempt to place microphones away from all sound on the ground and recording a sonic silence.

The submitted materials are:

- The recording of two flights using a spaced AB omni stereo pair with accompanying video footage in standard and 360-degree formats:
- Flight 2 is presented segmented in stereo sound with standard-angle footage; flight 3 is presented in full in stereo sound and 360-degree footage.

Research Contextualisation – previous balloon borne research and sonic exploration.

Sound recordists and composers have often looked to record hidden, discreet sounds in our environments for research, exploration, and to gather materials for composition. Chris Watson summarises his approach as "putting microphones where you can't put your ears" (Crawford 2013 para. 27) to capture biophony and geophony otherwise unheard by humans, using methods to hear within objects and beneath surfaces to make the 'inaudible' audible. In this research, an exploratory approach and previously untried sound recording technique utilizing a weather balloon is used to place an 'ear' in the sky to escape all sound and record the stratosphere.

Since Leon Teisserenc de Bort's early launches in 1896 (High Altitude Science 2019, para. 2) weather balloons have been a common method to collect atmospheric and climate data at altitude providing "precise measurements of temperature, pressure, humidity, wind speed and direction" (Australian Government Bureau of Meteorology 2018, para. 1). Numerous amateur flights have used weather balloons to experiment with tracking devices and to gather video footage of the stratosphere, for example, Project Horus in Adelaide (Project Horus 2016). As NASA says, weather balloons "can allow for excellent views of the heavens without any interference from the atmosphere. It is like being in space, but it costs a lot less than a rocket or a space mission." (NASA 2017, para. 1). The weather balloon recording method avoids sonic interferences on the ground by sending microphones far above the soundscape.

A weather balloon with GPS tracking that allows the balloon to rise independently to great altitudes is the only available means for microphones to be sent silently into the stratosphere. However, to my knowledge, the use of a weather balloon as a dedicated sound recording methodology to capture the sonic environment of the troposphere and stratosphere in high definition audio and within the human hearing range has not previously been explored. While a YouTube search on 'weather balloons' will present many examples of filmed

balloon flights in both standard and 360-degree formats, for example *Journey To The Edge Of Space* from Seeker VR (Seeker VR 2016), all either contain no sound or rely on inferior recordings. Wind distortion, microphones placed within the payload, sounds of the payload and loose materials moving in the winds are all common problems, while the use of the camera's inferior sound recording system presents problems in a lack of recording detail and high system noise.

An exception is the audio-visual work *Soundship (descender 1)* by Joyce Hinterding and David Haines (Haines & Hinterding 2016) in which a weather balloon flight is used to trigger and record an Aeolian wind harp based on the Japanese Unari (Haines & Hinterding 2016, para. 4). The intention is to create sound based on the "air pressure, wind currents, and gravity itself" (Haines & Hinterding 2016, para. 1). While recording the sound of the harp is the priority, some moments of near silence at the highest altitude were captured where there is no wind to trigger the harp. However, recording the stratospheric sound environment and an eventual silence is not the focus and issues with system noise remain within quieter areas of the recording.

Any other previous sonic research in the stratosphere using high altitude balloons is scarce and primarily concerned with infrasound below the threshold of human hearing. An example from the late 1940s was Project Mogul where balloons were used to place infrasound sensors in the sky to monitor potential nuclear testing and missile launches, one launch became the subject of the Roswell Incident where balloon debris were reported to be remnants of an extra-terrestrial UFO crash (Jepsen 2017, para. 6; Weaver & McAndrew 1995). Following this, a University of Michigan project documented the measurement of background noise levels and any sonic events at an altitude of 22 km using infrasound sensors (Bowman et al 2018, p.2). Daniel Bowman of Sandia National Laboratories uses high altitude balloons to capture infrasound data created by "natural disasters and nuclear explosions" (Jepsen 2017, para. 1). Further research by Bowman with Eliot Young of the Southwest Research Institute, investigates the sensitivity of infrasound sensors by positioning these 35km above coordinated large-scale ground explosions. The capabilities of the sensors

demonstrated through these methods presents the possibility of "pinpointing the location and size of events such as nuclear explosions, meteorite strikes, volcanic eruptions and sometimes earthquake ruptures." (Seismological Society of America 2017, para. 2). A high altitude balloon allows the infrasound sensors to be placed well above sonic interferences found on the ground making the detection of far away infrasound sources more reliable (Jepsen 2017, para. 3). A further advantage is a balloon borne sensor will travel with the wind and is less affected than a stationary sensor susceptible to the interference of winds blowing against it (Jepsen 2017, para. 5). Bowman envisages in the future:

> detectors could be used to monitor infrasound generated by nuclear weapons and could help enforce nuclear weapons bans…infrasound sensors could also be used to detect infrasound in a gaseous planet's atmosphere that could help scientists learn about that planet's interior and phenomena in the atmosphere such as meteor strikes and thunder. (Jepsen 2017, para. 10)

Sonic exploration beyond Earths atmosphere.

In furthering the notion of stratospheric soundscape research and exploratory sound recording, it is noteworthy that until NASA's 2021 Mars Perseverance rover (NASA 2019) sonic exploration beyond the earth's atmosphere within human hearing range was limited to one mono sound recording captured by the Russian Venera 14 Venus probe in 1982, recording sound on the surface of Venus before succumbing to the heat and pressure (V101 Science 2020; Leighton & Petculescu 2008). This recording is available on YouTube through V101 Science (V101 Science 2020). As summarised by Leighton and Petculescu, "whilst camera systems are almost ubiquitous, most probes have lacked any sensitivity to sound" (Leighton & Petculescu 2008, para. 2). Dr Carolin Crawford explains any supposed sound recordings of Space are sonifications of other data. Some examples from infrasound data are "sped up (sometimes by enormous factors) to be made audible" (Crawford 2011), while others "are conversions to sound of natural radio signals…or are representations of periodic phenomena converted into sounds so they can be appreciated" (Crawford 2011). Representing the data of a cosmic event as sound allows its properties to be

further understood “sound can be used as the medium through which some other time-varying non-acoustic signal (such as radio waves generated by Jovian lightning) is communicated to humans” (Leighton & Petculescu 2008).

Recordings transmitted by NASA’s Mars Insight lander in 2018 were described as the sound of wind on Mars. However, this data is recorded using sensors: an air pressure sensor that records low frequency fluctuations in air pressure as an electronic signal (Mashable 2018), while a seismometer captures the Martian winds vibrating the landers solar panels before being placed on the Martian surface (Mashable 2018). As recognized, these recordings are not captured with a microphone and neither are acoustic sound recordings of the wind blowing around the lander or over the Martian landscape. Both were raised in pitch to be heard and do not capture the soundscape of Mars but are sonifications of data.

However, in 2021 NASA’s Perseverance rover landed on Mars equipped with two DPA 4006 omni directional microphones (DPA Microphones 2021). The aim was to capture the sounds of descent, the function of the rover, and the Martian soundscape. The resulting sound recordings are available on the DPA (DPA Microphones 2021) and NASA (NASA 2021) websites. Unfortunately, for reasons unexplained, no sound was recorded on descent and landing. There are two recordings available of the rover driving on Mars, one is a raw unprocessed recording and the other is processed to remove the electronic whine of the rover (NASA JPL 2021). The raw, 16 minute example *Sounds of Perseverance Mars Rover Driving - Sol 16 (16 minutes)* (ibid.) captures the sounds of the rover but there are no recordings available of the rover driving on Earth for the listening public to compare. Previous recordings of similar driving on Earth may give a better overall understanding and further inform the recording, the function of the rover on Mars, and the propagation of this particular sound in the Martian atmosphere. Separately, general information is provided on Martian sound propagation accompanying processed examples of what sounds such as a bicycle bell may sound like on Mars (NASA 2021), but how these conclusions were reached and the replication of the sounds are not detailed accurately, the information given is an approximation. There is a further example, *Sounds of*

Perseverance Mars Rover Driving - Sol 16 (90 minutes) (NASA JPL 2021), of the rover driving with noise reduction processes to remove the electronic whine of the rover, however on listening the noise reduction is clumsy and extreme with the resulting reduction artefacts detrimental to the recording. This approach to over reduction is heard on other Martian recordings but there is no information available on the noise reduction processes used.

Winds of the Martian soundscape were also recorded, however a continual problem is the lack of wind protection on the microphones that degrades the recordings, covering details and interrupting the recording. There is no discussion of wind protection on DPA or NASA's online information and it is unknown why exactly this is lacking. However, David Gruel, an engineer at NASA's Jet Propulsion Laboratory, says in interview on NPR Radio:

> The only thing that we added is you take this grill off, which is used to help with wind noise and stuff. And the vendor put a fine mesh on the inside of it just to keep dust out of the diaphragm. (Martin 2021)

The reason for the removal of the most minimal wind protection, nor any thought into improved protection, is not explained and negatively impacts the recorded outcomes. Gruel hoped to capture the descent through the Martian atmosphere and the moment of landing (Martin 2021), but these details would be very difficult to capture without sufficient wind protection. As shown in the weather balloon recordings here, wind protection at even a low velocity descent is paramount to successfully recording the environment or functions of the process. The Martian soundscape can be expected to primarily contain the delicate geophony of winds of varying strength blowing across the landscape, similarly to the most remote desert locations in western New South Wales discussed in the previous chapter. The recordings of these areas show a remote soundscape can be extraordinarily quiet with any sonic details difficult to record, therefore great care is needed to avoid all wind distortion and limit system noise to record such delicate details. The Mars recordings available show this level of attention to wind has not been possible, they also portray a basic and limited

approach to sonic exploration; a microphone was placed on Mars, however limited thought was given to the process of sound recording.

It is a significant scientific achievement in sonic exploration to have a functioning extra-terrestrial microphone and the recordings do capture some of the Martian soundscape, but it is an opportunity missed and not utilized. The recording process and noise reduction is flawed and there is a lack of information on the process. Therefore, surprisingly we are still yet to explore in sufficient detail an alien soundscape through sound recording, particularly in regard to the exploration of Mars of which we have gathered an abundance of high-resolution images, yet still not the equivalent sound. Martian geophony could tell us more about the environment and enhance our experience of remote exploration, as Leighton & Petculescu state:

> Sound in the absence of vision contains complementary information that we often take for granted in many aspects of human life (from diagnosing the performance of a car engine as we drive, to estimating the ferocity of a rainstorm on the bedroom window at night, to monitoring the happiness of a baby hidden beneath the canopy of a pram). (Leighton & Petculescu, 2008)

The Weather Balloon Recording Method is a similar form of sonic exploration albeit restricted to the stratosphere. High definition sound recording is used to remotely explore a place where we cannot be and capture something we cannot usually hear, using a mechanical ear to observe and listen to the stratosphere. All sound recordings are supported by images but the priority is sound.

Balloon flight preparations – payload design and flight predictions.

A weather balloon flight is complex and separating the methodology into the areas of balloon flight and sound recording allowed for the collaboration with high altitude balloon expert Robert Brand. Brand's role concerns all aspects of flight in conjunction with the Civil Aviation Safety Regulations 1998 (CASR 2003) ensuring: wind conditions are suitable on the ground and in the jet stream through flight path predictions based on wind forecasts, notifying relevant

aviation departments of the flight for air clearance, provision of the balloon, helium, GPS tracking systems, launch and recovery of the payload. Sound recording concerns the development of a recording system and a method to house this in flight. Weight restrictions governed by the Civil Aviation Safety Regulations limits the entire payload to a weight of 4kg (Civil Aviation Safety Authority 2003), with GPS tracking needing 600g, the recording system and payload must stay under 3.4kg. A lighter load will also allow the balloon to reach a greater altitude.

Recording system and payload design.

Considering weight limitations and the potential for damage, a small stereo sound recorder is used with a stereo microphone technique taken from Chris Watson using two lapel microphones as a spaced omni pair (Watson 2017). Here two Sanken COS11 omni lapel microphones and a Zoom H4n recorder were used. The microphones are mounted in the shock mount of the microphone blimp to avoid any potential sound transfer from vibrations created by winds or the balloon. Wind protection is a priority with each microphone further and independently shielded within the blimp.

Figure 34: microphones in shock mounts with wind shields.

Lithium batteries must be used with additional external batteries for the Zoom sound recorder and GoPro camera to combat any loss of battery power caused

by temperatures of minus 40 – minus 60c. The recorder and batteries are housed in a plastic Tupperware container and mounted in sponge to some what insulate the recorder from the cold and impact of landing, with the microphone blimp connected by a short rigid rod. All connection points are insulated with rubber to prevent vibration transferring through the load. The potential of unwanted sound from the balloon is avoided with the payload and microphones positioned ten metres below the balloon. The GoPro camera is attached to the container with GPS transmitters attached to the balloon line near the balloon and away from the recording equipment.

Figure 35: Flight 1 payload, blimp is without wind shield here.

Flight and weather predictions.

The launch site is a cricket oval in the small town of Weethalle in Central West New South Wales. The sparsely populated flight area surrounding Weethalle has minimal tree coverage, and is selected for ease of payload recovery with no near by large bodies of water or deep valleys.

The balloon's launch, flight path, burst point and landing area is governed by wind. Predicting a flight path based on winds on the ground and at high altitudes ensures a safe landing zone that guarantees the balloon remains within the

designated airspace. On launch, the weather on the ground must be clear of rain to avoid sound recording or GPS tracking issues, and free of wind for a stable initial ascent. The flight path and distance is determined by the strength of the jet stream at altitudes of 11-12km and either assisted or countered by the direction and strength of the higher stratospheric winds. If the winds are too strong, not only may the recording be compromised, the balloon will travel too far for recovery and beyond the designated flight zone, in the wrong conditions the balloon may cover ground distances up to 300kms. Balloon inflation governs the ascent rate and burst point, in stronger winds inflation must be higher to reach the burst point earlier and land within the allotted air space, however, for recording purposes a slower ascent rate is preferred. In the same manner as Bowman's balloon borne infrasound sensors, the balloon and microphone blimp are carried with the wind. The main potential for unwanted wind sound is of drag created by a fast ascent, not the sound of wind distorting the microphones but air rushing around the box and microphone blimp as it rises, therefore, a slow accent is needed for minimal drag noise. Conversely, if the ascent rate is too slow there is the possibility of the balloon not reaching a high enough altitude to burst then continuously floating in the stratosphere and irretrievable.

Figure 3 shows an example of the Wind Speed and Direction forecast map from the Bureau of Meteorology. The winds depicted are at an air pressure level of 200hpa, equivalent to an altitude of 10 – 12km and within the Jet Stream. This shows suitable conditions for a third flight with the flight zone in Central NSW clear of any winds over 40knotts.

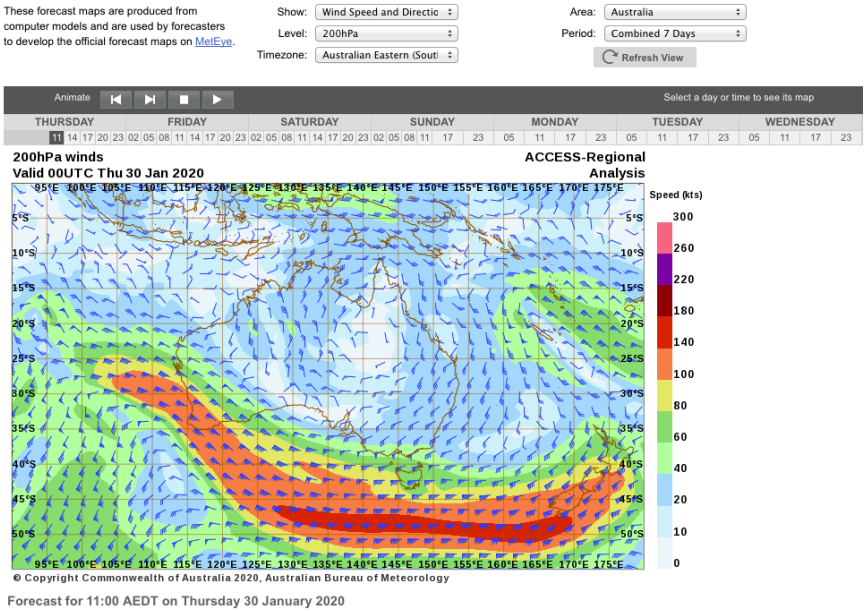

Figure 36: wind speed and direction map at 200hpa (Bureau of Meteorology 2020)

Figure 4 shows a flight path prediction demonstrating conditions unfit for flight that would take the balloon outside of the flight zone. This particular path shows a period of high winds that prevented a flight for over 6 months. In this example, the launch site is at the most western point of the flight zone at Rankin Springs, with the balloon predicted to burst South East of West Wyalong and land beyond the edge of the flight zone at Bimbi travelling 153km.

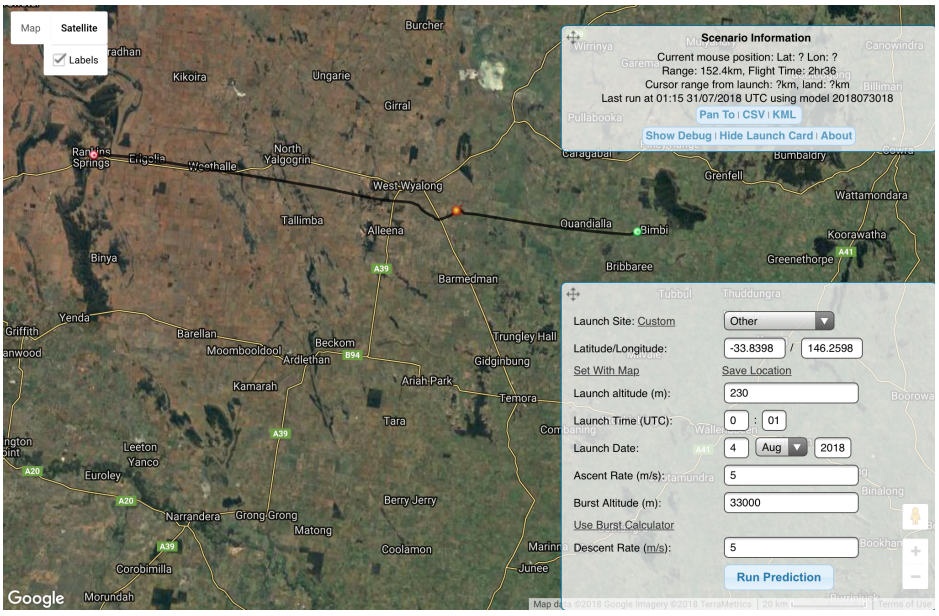

Figure 37: flight path prediction depicting unsuitable wind conditions for flight.

Camera and the role of image.

Figure 38: flight 2 GoPro still, high in the stratosphere at 32km just prior to burst

Figure 39: flight 2 GoPro still after launch

Figure 40: flight 2 GoPro still just prior to landing

Although captivating image effectively plays an accompanying role in providing visual information on the recoding process and environment to further inform the sound recording. The manner in which the footage is captured is relatively simple and quality of image is not a priority in this work, it is only through concept and placement that absorbing footage is recorded. However, the footage is aesthetically important in placing an 'eye' in the stratosphere to complement the 'ear' and brings an interesting and difficult to capture visual element to the sound recording. The dramatic footage also draws further attention to the concepts and methodology of the sound recording.

In viewing the work, ideally the sound recording is listened to and explored independently first, then accompanied by the synchronised image after. This allows a focus on the sonic details and lets the listener create their own image.

According to Chris Watson, “the pictures are better on radio” (*Conversations* 2017) and this is the intended approach here, the listener may first create their own interpretation free from the image and very literal visual information.

In regard to informing the recording process and sound recording, filming the location of the microphones and altitude informs what is heard. As discussed below, the footage from Flight 1 clearly depicts the source of problematic rotation sound showing the speed of the uncontrollable rotation as the camera spins. In flights 2 and 3, at lower altitudes potential sound sources on the ground can be seen providing useful information in relation to aerial phonography and what is heard. For flight 2, in addition to the GoPro, a 360-degree camera was introduced. This provided further information on the recording process by showing traffic on the ground, footage of payload stability during flight, and indicated wind strength through the movement of synthetic fur on the windshield. Before shutting down in the jet stream, the 360 perspective captured engaging footage of ascent. For flight 3 a GoPro 360 camera successfully captured the entire flight showing the above aspects of process as well as capturing the balloons expansion on ascent, balloon burst, and the balloon remnants spiralling behind as the payload parachutes to the ground. Additionally, two airplanes are seen flying by.

The general progression of all flight footage captured shows; the ground being left behind on launch and early ascent, rising through the clouds and troposphere, then into the stratosphere to burst point where the sky becomes black and the blue haze of the Earth’s atmosphere is seen. Pieces of the balloon are visible on burst the moment before the initial violent descent where the load flips and free falls until there is enough air pressure for the parachute to catch and slow the descent. The balloon then speeds through the troposphere and jet stream where it is buffeted by winds as the payload roars towards the ground. In flight 2, on landing the parched soil and dry crop is seen close up and with birdcall and gentle winds heard above the microphones, the GPS transmitters and parachute coincidently fall through frame to the ground, the return to life further emphasised by an ant busily walking into picture to inspect the new

arrival. In the 360 footage of Flight 3, with the ability to look all around, the viewer is artificially placed in the sky. When viewing the work through VR goggles it is an immersive experience that, as witnessed at a viewing with friends, can put the viewer off balance. We see the balloon burst above outward in a circular motion as the payload free falls. The payload again speeds through the lower stratosphere and troposphere, the majority of the burst latex balloon is seen spiralling behind, and then again on impact the microphones return to the soundscape on the ground and life.

The visual is certainly important to final works and presentation, as well as necessary in informing the sound recording. It is an important aspect of the methodology but it is secondary, the more common prioritisation of the visual in weather balloon flights is flipped onto sound.

Figure 41: Flight 3 rising through the clouds.

Flight 1 – 4th March 2017.

Submitted sound and video excerpts are included and referenced below.

The flight duration was 2h14mins, based on GPS data the balloon travelled 21kms laterally, reached an altitude of 32kms just above the ozone layer and halfway into the stratosphere, with the payload successfully retrieved from a farmer's field. While interesting, this flight was in part a test for an untried recording method; areas to be improved for future flights were expected and identified.

Figure 42: the highest point of flight 1 just prior to burst at an altitude of 32km, while certainly present, the curvature of the Earth is enhanced by the GoPro fisheye lens.

Figure 43: Flight 1 flight path.

Payload performance.

The payload successfully housed the recording system throughout the flight, nonetheless, two significant design problems that impacted outcomes were identified to be resolved for future flights.

Of greatest impact was the sound of high-speed rotation caused by air rushing around the microphone blimp as the payload spun uncontrollably (See submitted video file: 4.1 flight 1_video footage of out of control spinning). While some gentle spinning may occur in flight, emerging winds at the time of launch caused the payload to skim the ground after release and set it spinning, and with the mass of the load centred, spinning was encouraged. This rotation sound is most evident in the recording at lower altitudes, while at higher altitudes of minimal wind and thinner air where the spinning is slowed, it is not apparent and the recording is clear. However, at these highest altitudes just prior to burst, rotation also raises concerns regarding the potential for sound transfer from the balloon to the microphones caused by tension generated through continued turning and tightening in the balloon line.

It was discovered to minimise rotation for future flights, a two-metre balancing rod with a small weight at each end would stabilise the load. As a comparison, a ballerina can slow their spinning when straightening their arms outward,

decentring mass by spreading weight. A swivel would also be used to decouple the balloon from the payload so any potential spinning created by the balloon will be independent of the payload.

A second impact on the recording caused by design fault is the sound of whistling in the gentler winds at high altitude. This was caused by wind blowing through holes drilled into the plastic container as connection points for the balloon line, and to compensate for air pressure increases within as the air outside thins, if there is no means for the air to escape the load may explode under pressure. To resolve the issue any holes are to be filled with sponge to allow airflow but prevent whistling.

Recording system.

Minimising noise floor in the recording system was identified as the main area to improve. While noise reduction techniques can isolate and remove unwanted system noise in post-production, the preference is to limit noise during recording. This is of specific necessity when recording such quietude and first became apparent in this research while recording interiors and remote areas on the ground where the soundscape is very quiet. With such minimal sound entering the microphones at high altitudes, the threshold of the recorded sonic environment and system noise is emphasised, blurred, and explored. As found in recording interiors and remote locations, system noise begins to blend with and sounds similar to the wind, to the point where the soundscape and noise floor are indiscernible.

To begin an analysis of flight recordings, noise prints of the recording system were collected in an anechoic chamber within the Acoustics Laboratories at the University of Sydney. System noise is isolated through three recordings of each stage. First, the entire system comprising of the Sanken COS11 microphones, EMP5 Ambient adaptors (used to convert the power and connection type of the microphones), and the Zoom H4n recorder was recorded. Following this, the adaptors and recorder were recorded without microphones, then the recorder

alone. These prints allow for a full understanding of system noise at each connection and through this process, the Ambient EMP5S adaptor was identified as a main source of system noise to be removed. The PAZ Frequency analyser images below show the stages of noise floor in the recording system.

Figure 44: noise floor of microphones, adaptors and recorder.

Figure 45: noise floor of adaptors and recorder, removal of microphones presents a decrease between 62Hz – 15Khz, 62Hz and below remains and is identified as noise generated by the recorder as shown in the following.

Figure 46: noise floor of recorder only showing a decrease in frequencies above 62Hz.

Recording analysis.

Areas of note include launch and recording issues caused by rotation sound, the final birdcalls as the balloon rises, the diminishing winds at high altitudes, the quietest areas of the recording just prior to burst, the burst of the balloon, initial decent, and landing. As outlined, the main issues in the recording are the rotation sounds on ascent caused by the payload spinning and system noise in quieter areas, both of which make hearing other details difficult. At the highest altitudes in the quietest areas, the threshold between system noise and the sonic environment is most apparent. To listen below the noise floor to the recorded environment, the system recordings gathered in the anechoic chamber are used as both an aural reference to manually minimise noise by ear, and as noise prints for reduction. Noise reduction software used is again the Waves WNS Noise Suppressor multiband noise reduction (Waves Audio 2021) when working subjectively by ear, and the iZotope Spectral Denoiser (iZotope 2021) used with learnt noise prints.

An excerpt of note is the quietest section of the flight at an altitude of 32km just prior to burst. With an extreme playback volume used to hear details, within the recording are low-level sounds at 125Hz from an undetermined source. (See submitted sound file: 4.2 Flight 1_unknown high altitude sounds.) The tension in the balloon line created by spinning is thought to be a potential cause, however,

vibration caused by gradual tension increases would need to be significant enough to transfer along the ten metre balloon line, through the payload, past each insulated connection point, via the shock mounts and eventually to the microphones making it a difficult journey for any vibration to affect the recording. Another thought is the source of the sound may be that of a plane flying approximately 23kms below, further emphasising the difficulty in escaping anthrophony. But it is still not certain exactly what this sound is.

Figure 47: pieces of the latex balloon after burst.

Reflection.

This first flight functioned as an initial experiment into an untried field recording technique with all outcomes providing a solid grounding for further development. The recording system was examined with options regarding recorders and microphones presented, as was the design of the payload to prevent unwanted spinning, whistling, and excessive drag as the balloon rises. Significant research outcomes were captured and this first flight was successful with the methodology executed and developed. However, the question of successfully placing microphones away from all sound is undetermined given the unknown low frequency sounds heard at the highest altitudes.

Flight 2 – 6th October 2018.

This works is submitted in segments. Footage should be viewed with the analysis below but also explored at will. See video library:

4.3 Flight 2_video excerpts of flight

This flight was delayed for six months due to strong winds in the jet stream and lower stratosphere. Launching from the same site at Weethalle, this flight reached a higher altitude of 33.5km, travelled 37km North West with a flight time of 2h30m. Outcomes of the first flight regarding payload design and the recording system were addressed and improved upon with all adjustments greatly improving the flight and providing strong outcomes.

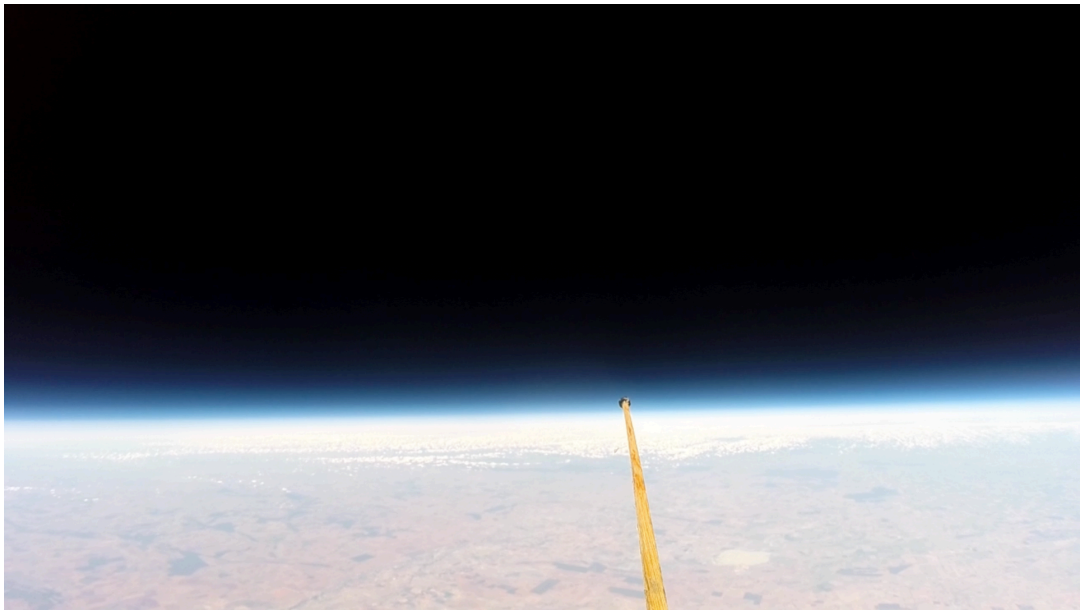

Figure 48: image from Flight 2 showing part of the balancing rod just before burst at an altitude of 33km

Payload adjustments and performance.

A similar payload design taken from the first flight was used with adjustments focusing on stabilisation through weight distribution and decoupling the balloon and payload. The use of a two metre stabilising rod positioned across the load with a small weight at each end was used to great effect to distribute mass away

from the centre and help counter spinning. In addition, as demonstrated in *The Use Of Swivels In High Altitude Ballooning* (Hedges 2015), the balloon and payload were decoupled via a sensitive, silent ball bearing swivel to allow the balloon and payload to turn independently of each other as they rise. These two additions greatly minimised rotation and presented distinct improvements in the recorded outcomes. Whistling was also eliminated with sponge used to plug any holes drilled in the box for cabling and air pressure changes.

Figure 49: Flight 2 payload, image taken from the 360 camera.

Recording System.

While the same recorder, stereo technique, mounting, and wind protection were used, a necessary alteration to the recording system was to remove adaptors that increased system noise, as a result the Sanken microphones were replaced with a matched stereo pair of Fel Clippy XLR EM272 microphones (Fel

Communications Ltd 2021). While the effect of cold temperatures on batteries is understood, the effect on recording equipment was relatively unknown so it was of added benefit to test the functionality of different microphones in the extreme cold. Obtaining accurate information on such low operating temperatures of the equipment proved difficult. The Zoom H4n sound recorder manual makes no mention of a lowest operating temperature but does state "avoid using H4n in environments where it will be exposed to: Extreme temperatures, heat sources such as radiators or stoves, high humidity or moisture, excessive dust or sand, excessive vibration or shock" (Zoom 2014). GoPro also provide only minimal information saying, "we do not have any official extreme temperature ratings for the camera. In colder temperatures, the main concern is reduced battery life" (GoPro 2019). While the Mi Sphere 360 camera kit specifications give an operating temperature range of "-10c to 45c" (Xiaomi 2019). In the minus 50 – minus 60c of the jet stream equipment performance is therefore somewhat an unknown, it is also difficult to test pre flight given the difficulty in replicating such temperatures. At this stage of the methodology, both sets of microphones used functioned flawlessly, developing confidence in the functionality of microphones in cold temperatures. The Zoom recorder also functioned throughout both flights, however the Mi Sphere 360 camera shut down just beyond the jet stream. The internal and external batteries still contained charge and the camera was not damaged so it is unknown what caused the camera to shut down. One possibility is the camera may have become too hot in an attempt to retain heat and shut down due to overheating. This failure continued concerns on the unpredictable performance of untried equipment in such cold temperatures.

Recording analysis and the introduction of sonic height perspective.

Adjustments in payload design made for a greatly improved recording that asks further questions. An initial development is the concept of listening to environments from above, or Aerial Phonography. In 2007 British sound designer Simon Keep explored the notion of aerial phonography by recording a hot air balloon ride as a sound walk from above (Keep 2007). But here the

technique is taken further removing the sounds of the hot air balloon, rising independently to higher altitudes, and using a stereo recording technique that specifically records the environment from above as opposed to the usual within. The idea is to record the environment not a balloon flight. By eliminating the rotation noise heard in the previous flight, immediately after launch the notion of sonic height perspective is introduced. With the microphones positioned above, it is possible to listen down to the soundscape below. At this stage the camera footage shows only one car in a sparsely populated landscape, but the recording presents a different perspective. As shown in the accompanying footage of flight 2, while the microphones rise birdcall quickly become louder, dogs and roosters can be heard in unexpected detail at altitudes of approximately 3km, and the distant anthrophony of traffic and various machinery begin to combine in the sky with an increasing volume not heard on the ground. Individual sounds may still be heard but details and definition are gradually lost as microphones rise further. (Refer to the submitted video file: 4.3.1_launch and sonic height perspective.)

During the warmer daytime temperatures of launch, refraction allows sound to freely propagate upwards (Ingard 1953), contributing to the increase in amplitude and combination of sounds heard in the recording at these altitudes. The distance between the microphones and sound sources on the ground gained through altitude is a further contributing factor and presents a much wider listening perspective and greater breadth in the recording. The focus is switched from the individual sounds heard when within the immediate soundscape, to a combination of sounds from the wider surrounding soundscape heard in such a manner only through the advantage of height. The removal of acoustic surfaces and obstacles allows for an uninterrupted path to the microphones with no influence from surfaces of reflection or absorption that may alter the source sound. As Barry Blesser states regarding the absence of a physical space:

> there are real environments that exhibit auditory spacelessness to varying degrees. Being suspended 300m in the air from a skyhook is an obvious example of such an environment. Its acoustic space is without sonic reflections, resonances or any object to influence sound waves. (Blesser & Salter 2006 p. 18)

A previous example of thought on sonic height perspective and listening down is found in George Prochnik's *In Pursuit of Silence: Listening for Meaning in a World of Noise* (Prochnik 2010). Prochnik refers to Dr William Braid White, director of research at the American Steel and Wire Company, who at a meeting of the American Association of the Advancement of Science in 1931, observes the city din by listening from above. According to Prochnik "Dr White encouraged every member of his audience to go to the twentieth story of a New York skyscraper, open a window and lean out" (Prochnik 2010, p.109). Dr White is said to have described his own experience as "after a while he will notice that the crashes, bangs, and clatters that, upon street level, come as a succession of shattering blows upon his ears, now begin to blend into a single continuous roar" (Prochnik 2010, p.109). Within this roar is what Dr White refers to as the low frequency "ground tone" (Prochnik, 2010 p.110) that may be ascribed to a musical note. This roar and tone, formed by the culminating cacophony of the human and industrial function, is only heard in such a manner through the perspective of height created by the skyscraper, and influenced by the surfaces, architecture and climate to create a unique city din.

But White talks of the act of listening not recording. A developing methodology from this research investigates the possibility of removing the skyscraper, or Keep's hot air balloon, and advancing aerial phonography by placing microphones immediately above a soundscape using tethered balloons to record environments from different stationary heights. The proposition is to conduct a thorough investigation of soundscapes from above using a portable aerial phonography system. What is the sound of Mumbai or London when recorded from above? Can we take the same approach to natural place? Francisco Lopez's *La Selva* (Lopez 1998) captures aspects of the Costa Rican rainforest so is logically recorded within the soundscape, but what could be heard if the forest was recorded from above and how would forests, deserts and other natural environments sound from above and compare? What can Aerial Phonography tell us about an environment in comparison to Aerial Photography? The recording of this second flight proposes a future development in the

methodology by using a balloon tethered to the ground and released to altitudes of 100, 200, 500, to 1000 meters if possible to gain the necessary height perspective to listen down and record from a static location above. An initial obstacle to this is, what kind of material is light enough to allow a balloon to be tethered to the ground yet reach an altitude of 1000 metres?

Continued analysis of the flight recording shows the gradual elimination of primary sounds in increasing winds as the microphones ascend seen in example 4.3.2_ wind. Biophony is eventually left behind with disappearance of the final birdcalls, the surrounding anthrophony continues with altitude and refraction before its dissipation, until we are left with only the sound of winds and the constant low-level sound of drag as air rushes over the ascending payload. The layers of the soundscape are peeled back and the sounds of life are eventually left behind through the remoteness of altitude.

In example 4.3.3_into the jet stream the payload continues through the heavier wind gusts of the jet stream, then up to the lighter stratospheric winds in 4.3.4_high alt winds, until these and the ascent drag in the thinning atmosphere eventually cease as shown in 4.3.5_final winds. Seemingly, only the anthrophony of system noise with no discernable sonic environment is heard within the recording. Nevertheless, after noise reduction, there is still a presence around 2000Hz and below (figure 10). Playback volume is extreme (up to +12dB) to be heard, or seen in an analyser, thus system noise is exaggerated. Therefore it is unclear if this is the sonic environment of the stratosphere or simply part of system noise.

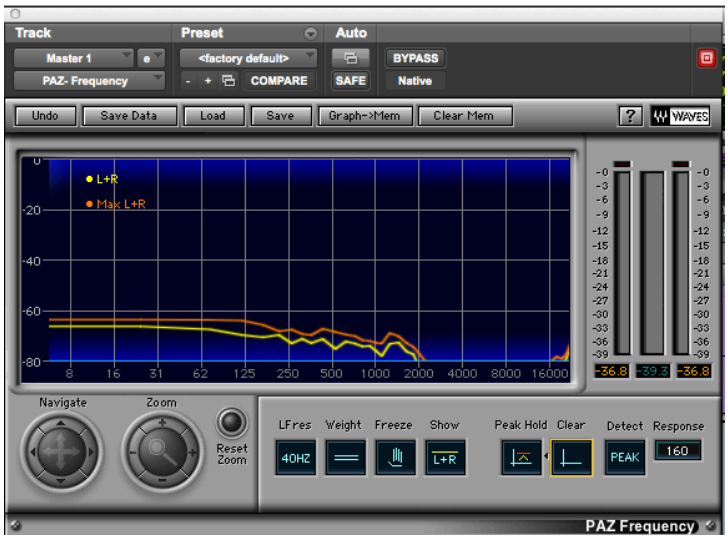

Figure 50: Flight 2 frequency analyser showing frequencies at an altitude of 32km.

The highest altitude, just prior to burst, is the peak of silence within the bounds of each balloon recording as shown in 4.3.6_highest alt and burst. It is the point of each flight where the microphones are the farthest from sound sources on the ground, the atmosphere is at its thinnest and the wind eventually dissipates to seemingly sonic silence. At this altitude in Flight 2 the threshold of system noise and the sonic environment is reached. An anechoic chamber noise print is used in noise reduction to remove system noise and locate any potential environmental sound. Playback levels used are extreme to locate any environmental sound, if the playback volume is returned to levels used at launch, only minute sound emit from the loudspeakers.

But there still appears to be a low frequency sonic environment in the stratosphere of sorts that posses further questions. Can the winds in the stratosphere or jet stream below be heard simply through the movement and strength of air wrapping around it self, or are surfaces necessary for wind to blow around to roar or howl? In flight 1, is it in fact the sound of a distant airplane 20km below that can be heard at the highest point? Or is it a truly silent environment with the recording system taking to its limit and these sounds simply system noise? If sound is present at altitudes above 30km what exactly are we listening for? What, if any, impact does the low temperature and thin atmosphere with no surfaces for absorption or reflection have on the timbre of a sound? If there are no altering influences, why is the sound of the balloon burst

in the stratosphere drastically different to a burst on the ground? On the ground a weather balloon will explode with a sharp high crack, while in the stratosphere it is dull puff. To begin to answer these questions sound propagation research within and outside of Earths atmosphere is necessary.

Figure 15 below presents data on altitude, environment and speed of sound but will these factors present any frequency or dynamic changes to a sound?

hPa (mbar)	height (metres)	height (feet)	temperature (degC)
» 10	31 055	101 885	-45.4
» 20	26 481	86 881	-50.0
» 30	23 849	78 244	-52.7
» 40	22 000	72 177	-54.5
» 50	20 576	67 507	-55.9
» 70	18 442	60 504	-56.5
» 100	16 180	53 083	-56.5
» 150	13 608	44 647	-56.5
» 200	11 784	38 662	-56.5
» (226/ISA TROP..	11 000	36 091	-56.5)
» 250	10 363	33 999	-52.3
» 300	9 164	30 065	-44.5
» 400	7 185	23 574	-31.7
» 500	5 574	18 289	-21.2
» 600	4 206	13 801	-12.3
» 700	3 012	9 882	-4.6
» 800	1 949	6 394	2.3
» 850	1 457	4 781	5.5
» 900	988	3 243	8.6
» 950	540	1 773	11.5
» 1000	111	364	14.3
». (1013.25/ISA MSL	0	0	15.0)
» 1050	- 302	- 989	17.0

Figure 51: International Standard Atmosphere pressure, altitude and temperature information up to 31km. (Avci 2015)

Research into temperature shows the aforementioned sound refraction as an example of how temperature affects sound propagation (Ingard 1953). But refraction concerns trajectories and not the potential for temperature to audibly alter sound. It is understood sound propagates better through a thicker medium such as water but what, if any, is the audible effect of a thinner atmosphere?

If we look beyond Earths atmosphere again, an example of the predicted audible effects of atmospheric conditions can be found in the atmosphere of Mars; a combination of low air pressure, low temperatures and high levels of Carbon Dioxide at 95% (Hanford & Long 2009). Outcomes based on the Direct

Simulation Monte Carlo method to model the acoustics of Earth, Mars and Saturn's moon Titan by Dr Amanda Hanford and Dr Lyle Long presented at the 151st Acoustical Society of America meeting show:

> DSMC is essentially able to capture all physical properties of interest to the sound propagation on Mars, as well as the details of sound absorption. Our results show that the absorption of sound on Mars is 100 times greater than it is on Earth due to differences in molecular composition and lower atmospheric pressure. (Hanford & Long 2006)

An aural comparison based on modelling is provided as "the sound from a lawnmower on Earth can travel a few miles before it gets absorbed into the atmosphere. This same lawnmower on Mars would produce a sound that could only travel a few hundred feet" (Hanford & Long 2006). According to Hanford "the lower pressure makes it so sound doesn't travel far" (Phys Org 2006), while "a sounds lower pitch is the result of the differences in the speed of sound. This is because of the Red Planet's atmospheric makeup – mostly carbon dioxide" (Phys Org 2006). Therefore, a decrease in propagation and pitch will only occur in combination with low air pressure, low temperatures, and high levels of carbon dioxide. Based on this modelling of the Martian atmosphere, without the presence of high levels of carbon dioxide, air pressure and temperature alone in the stratosphere are thought to have no effect on a sounds timbre. Furthermore, as shown in Figure 15 the temperature begins to increase in the ozone layer to minus 23c, thus bringing the speed of sound propagation closer to that on the ground.

It may seem excessive to delve into distant detail but an investigation into temperature and air pressure allows for a better understanding of the sonic environment of the stratosphere. In doing so factors are eliminated and the conclusion is simply, environmental conditions in the stratosphere will not audibly affect sound. The sound of a distant airplane will propagate the same as it does on the ground but without surfaces and obstacles to alter it. However, it is still unknown as to why exactly the sound of the balloon burst in the recording is quieter and contains less high frequencies in comparison to the sound of a balloon bursting on the ground. The best hypothesis thus far is simply sound of

helium (not air) bursting out into an environment of no surfaces is the cause of this change in timbre.

Returning to an analysis of the recording, directly after burst at 36secs in excerpt 4.3.6_highest alt and burst, a brief moment of still occurs where the balloon is no longer ascending and the payload reaches a moment of weightless calm before the violent, high speed descent back to life and sound on the ground. The load is flipped and buffeted as it free falls reaching high speeds with not enough air for the parachute to slow decent, until eventually air pressure increases and the parachute catches. The microphones descend for thirty minutes as the load roars through the lower stratosphere and in to the jet stream as descent winds wrap around the microphone blimp and plastic box, 4.3.7_falling through jet stream and 4.3.8_final descent. On the heavy impact we are once again fully emerged within the soundscape on the ground; birdcalls, gentle distant anthrophony, and winds blowing above the microphones through leftover dry crop can be heard 4.3.9_landing. An ant walks into the frame of the image reinforcing the return to life on the ground.

Reflection

This second flight was greatly improved upon and presented strong outcomes that posed further questions and new research paths. A key development was the refinement of payload design that allowed for research into sonic height perspective and Aerial Phonography.

But again, it is still unclear whether a true sonic silence has been located in the stratosphere. It is believed there is still a sonic presence however, if there is sound present, this particular recording system cannot capture it in detail. The system has been taken to its limits with the distinction between the sonic environment and system noise unclear. Alternative recorders and microphones will be explored for future flights to see if these present further details.

Balloon Flight 3 – 14th February 2020.

Figure 52: flight 3 payload at its highest point of 28km in the stratosphere.

See submitted materials:

4.4 Flight 3_360 video.

This flight is submitted in its entirety, taking influence form the genre of Slow TV (McCrory 2020). The viewer should follow the analysis below for information on key aspects but also explore the flight at will. The flight can be viewed in 360 through a playback software such as VLC Player and can be viewed through VR goggles. For submission purposes, this is a low-resolution video version to limit data. For any potential screenings on larger 4K screens a full resolution version is available.

An addition to this flight was altitude data for the entire flight. Previously only the highest altitude was known with any other altitudes approximated based on ascent rate and time. For altitude information see appendix item 3.

Due to wind and overnight rain, this flight was launched east of Weethale at Barmedman in Central NSW, the payload landed approximately 15km North East

and reached an altitude of 28km, a lower altitude than previous flights but with no bearing on outcomes.

Figure 53: rising above Barmedman just after launch, the launch site is next to the cricket field in the bottom left third of the frame.

The final progression in the methodology was to ambisonic sound recording accompanied by 360 degree footage, and again in stereo with standard footage. The move was to utilise instruments that would give greater breadth. An ambisonic microphone was thought to provide interesting results specifically in regard to sonic height perspective at lower altitudes, while also capturing a wider area of the stratosphere. The 360 footage was to allow for greater observation of the process, and of course provide enthralling footage of a trip into the stratosphere, while also complimenting the ambisonic format as a logical progression.

Sponsorship was obtained through Rode microphones and Lectrosonics with both interested in playing a role in a previously untried recording method that would also function as a test for the equipment in extreme conditions. A Rode NT-SF1 ambisonic microphone was provided by Rode in exchange for a 360 image of the microphone in the stratosphere with full reference to this research. While Lectrosonics provided a SPDR stereo recorder in return for permission to

reference the use of their recorder within this research. This smaller, lightweight recorder also created room within weight limitations to allow for both a stereo and ambisonic recording system.

Payload adjustments and performance.

The design of the payload was adjusted for aerodynamics and weight with attempts made to further limit the sound of the recording process. The Tupperware boxes that housed the recorders and batteries on previous flights were replaced with an empty rugby league football. The egg shaped football was thought to provide better aerodynamics and limit the sound of ascent drag caused by air rushing vertically passed the load as it rises, while allowing horizontal winds to blow around the ball with minimal friction. The lighter football skin also created additional room within weight restrictions to allow for two recording systems. Just prior to launch, all recorders and batteries are placed in the football and surrounded by sponge with the football simply taped shut for flight. The use of the horizontal blimp containing the AB stereo pair may have compromised the aim for better aerodynamics however the football shape did minimise the sound of ascent drag as shown in the recording.

A rubber mount was used to attach the ambisonic Rode NT-SF1 microphone to the threaded rod similarly to previous designs. Given the susceptibility to wind distortion, three layers of wind protection were used to protect the cardioid capsules. The 360 and standard GoPro cameras were mounted similarly to that in Flight 2. Other successful aspects of the design were retained including the use of the ball bearing swivel and balancing rod, to save weight the GPS transmitters were used as balancing weights. Overall, adjustments made to the payload minimised the sound of ascent drag and further stabilised the load in flight. On the morning of flight, due to overnight rain, unfortunately the football needed to be wrapped in plastic bubble wrap then heavily taped in the event it landed in water.

Figure 54: Flight 3 payload during construction with the stereo blimp, Rode NTSF1 ambisonic microphone and GoPro 360 camera.

Figure 55: The payload in preparation for launch

Recording system.

Both stereo and ambisonic recording systems were used. For this flight the Lectrosonics SPDR recorder and two Sanken COS11 microphones connected directly without adaptors were used for the stereo recording. The NT-SF1 ambisonic microphone required a lightweight four-track recorder and a Zoom H6 was used.

The results show the methodology is best suited to the more robust lapel microphones as an omni AB stereo pair. While the ambisonic microphone does provide greater breadth as intended, it doesn't capture details, has a higher noise floor, and suffers from wind distortion at lower altitudes. Where the winds are lighter and air thinner the ambisonic NT-SF1 preformed as it should. However, for any potential future flights a surround array using four omni lapel microphones, or a binaural approach would be used.

Recording analysis.

Flight 3 was also largely a success; the progression to 360-degree formats is of value in both the results and in determining the best recording technique for the methodology. Similar noise reduction processes have been carried out, however for submission I opted for a version as unprocessed as possible for authenticity to the recording, noise reduction is minimal to ensure noise floor is reduced but the soundscape not altered. If presented as a film or in installation, noise reduction and equalisation would be furthered and the recording designed to suit creative intentions. At the time of launch for this flight winds prevented the desired one-minute of quiet with no anthrophony before release with the balloon needing to be launched between gusts. On launch, a passing truck and car on the roads near the launch site seen in the 360 footage are heard loud and in detail as the microphones rise above. This was not necessarily the intended anthrophony free soundscape for launch, however, given the methodology investigates an escape from primary sound, this anthrophony appropriately accentuates the concept of leaving sound behind on the ground and in the end is a good inclusion.

An unwanted sound of the process apparent early is whistling in the right side of the stereo recording at lower altitudes. This may be seen as somewhat distracting given it presents the sound of the recording process and ideally, as in flight 2, this should not be present. Alternatively, the gentle whistling may also be thought to perfectly underscore rising through the sky. The wind protection used here was the same as previous flights and the source of this whistling is unknown. It does not necessarily degrade the outcomes but it is observed as a sound of the process. The left channel does not suffer from whistling and maybe isolated and centre panned in the mix to hear the soundscape alone in mono.

As stated, the ambisonic microphone suffers from wind distortion at these lower altitudes but nonetheless the sound recording is still of interest given the added breadth although nothing was specifically gained. Overall, the ambisonic

microphone is shown to be too susceptible to the wind but still provided results of interest.

The necessary inclusion of plastic wrap surrounding the payload given the heavy rain overnight created the unwanted sound of the plastic contracting in the colder temperatures as it rises. Noise reduction techniques in the final mix successfully minimised this crackle, however, it is another presence of the recording process that would be better avoided.

The sonic progression of the flight is similar to the previous. Again, from launch and the first five minutes aerial phonography is of interest and, as in flight 2, demonstrates the sonic vantage point garnered by height. The initial sound of traffic on launch dominates providing a clear example of listening from above. Birdcall is once again heard with increasing volume and greater breadth until it dissipates with altitude. Also as in flight 2, we hear farm animals, traffic, and machinery from the surrounding area culminate above the soundscape as the microphones rise to a higher vantage point. Then, the only sounds heard from the ground are of distant anthrophony below, at one point a truck engine is heard with the microphones above low clouds at 4:45 indicating the altitudes such engine sounds can propagate to. Given this example captures a sole truck in the sparsely populated country, the propagation of sound into the stratosphere from a much louder city must be significant. This poses a further question; to what altitude can soundscapes of significant volume propagate?

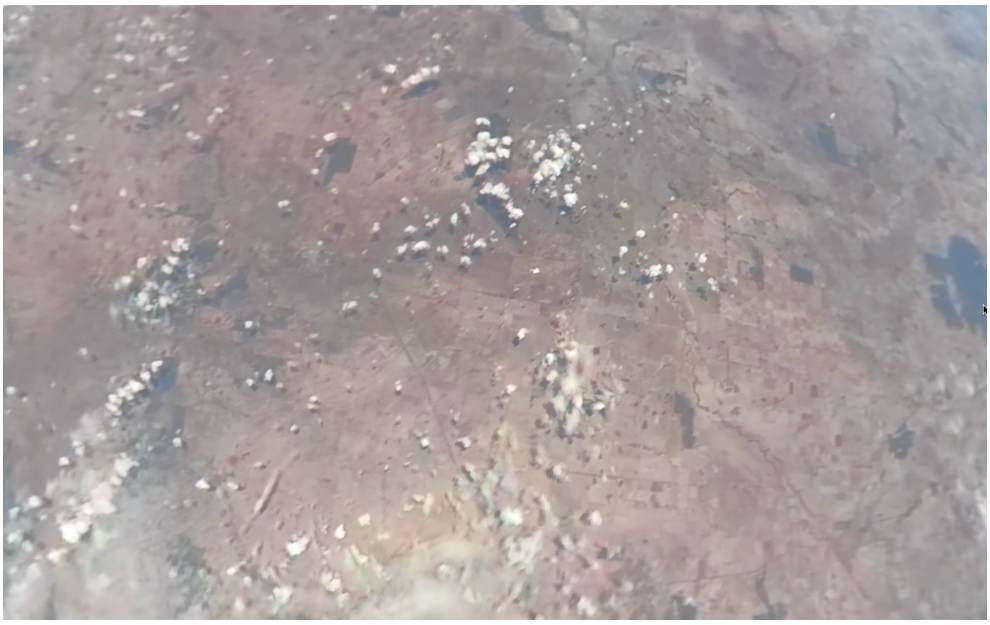

Figure 56: looking to the ground from the stratosphere in flight 3.

This flight contains more airplanes than the previous flights. The passing planes were not anticipated but are a dynamic inclusion. One provides a rare recording of a commercial aeroplane recorded at approximately 1 – 2km distance with engines at cruising speed in the jet stream free from any influence of surfaces to absorb or reflect sound, the airplane is seen in the 360 footage at 42 minutes. (This is also submitted in standard GoPro footage format in file 4.5 Flight 3_plane fly by at 11km.) Eventually gentle winds begin to dominate through the jet stream and up into the stratosphere until these also largely dissipate. From 1 hour and 17 minutes until burst there are long periods free of wind and airplane engines and these are the quietest areas of this flight. At the highest areas of the flight from 1:53:00 three minutes before burst a distant plane approximately 16km below is just audible. It is of note how the planes, especially those at higher altitudes, can pull the listener from the stratosphere. Just as an unwanted sound may pull the viewer from a film, or the sound of distant traffic may ruin the beauty of a remote natural place, the sound of a plane in the stratosphere jolts the viewer back to earth.

As found in the previous flights, when playback volume is increased dramatically a similar sound is present in the form of low to mid frequency rumblings at the highest altitude with the exact source of this unknown, however, this may still

simply be system noise. Although there is a distant plane at the highest altitudes and system noise, it is still believe there is a separate sonic presence in the stratosphere, but exactly what this is made up of is still not known. Again the possible causes of this are: wind, distant airplanes, or anthrophony rising from the ground, however, anthrophony in such a quiet country location rising to such altitudes is considered unlikely.

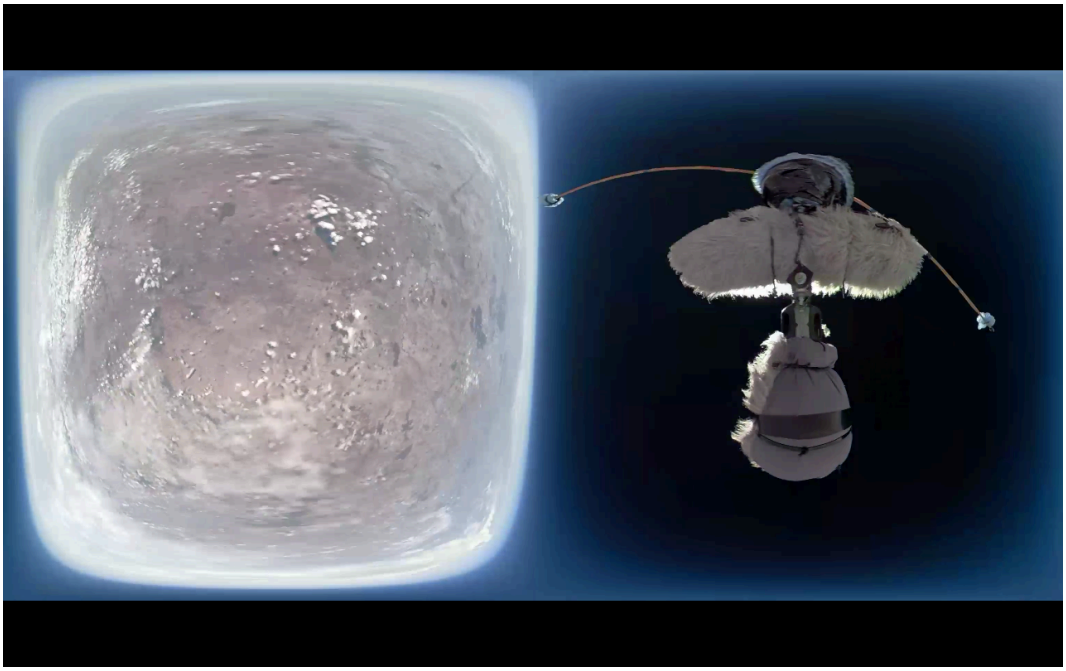

Figure 57: a still from unstitched 360 footage, this is just after burst where the payload is free falling and the camera being flipped, the violent spinning while zooming all the way out created this unexpected image of the payload in one lens and the ground in the other.

The sounds of burst and descent at 1:56:07 are similar to previous flights with the load initially violently flipping, and then stabilising at lower altitudes as the parachute takes effect. The 360 angle allows us to see the circular motion of the balloon burst and the punctured balloon spiral behind the payload as it descends. The sound of air rushing by the microphones creates intense roars as the payload hurtles through the stratosphere then troposphere. This in itself provides ample material for future composition capturing the sound of microphone parachuting through the sky. At 2:27:31 the payload lands on a field and back within the soundscape on the ground of gentle winds and birdcall.

Figure 58: Payload, parachute and balloon as it landed

Reflections.

The rare nearby recording of an airplane at cruising altitude is an unexpected inclusion of interest and demonstrates the difficulty in escaping anthrophony and particularly airplanes. The move to ambisonic sound recording with accompanying 360 degree footage is also of value and lays a path for further progression to perfect the methodology in surround sound formats. Again, the best technique for the methodology to this point is a spaced AB stereo pair using omni lapel microphones. For any potential future flights a surround array comprised of omni directional lapel microphones maybe used, or binaural techniques. If the flights recorded here are to be presented in multi channel surround formats this may be achieved from a mix of the omni stereo pair recording.

Finally, it is significant that all equipment used for this third flight did not malfunction in the extreme cold, allowing the methodology to be developed to a level of confidence for repetition. This is a difficult field recording method always

susceptible to the weather and soundscape conditions and equipment reliability is paramount given there is no opportunity to adjust after launch.

Conclusion.

In concluding, what is the soundscape of the stratosphere and is there a sonic silence? Are the low to mid frequency rumblings in fact the sound of system noise or are these environmental? It is difficult to determine the threshold of system noise and the sonic environment and separate the two. Recording practice on the ground between Bourke and White Cliffs in northwest New South Wales also show it is very difficult to capture such a low level environment, but in the case of these ground locations, it is possible to also engage in detailed listening on location within the environment that helps inform the recording in postproduction, providing a better subjective understanding of the noise floor and soundscape that influences the ensuing equalisation and noise reduction approaches. But of course we do not have this listening luxury in the stratosphere.

Flight 3 marks the end of the recording methodology within this body of research. The methodology has developed significantly and successfully over three flights using stereo and ambisonic recording techniques. The stereo recording methodology has been developed and progressed to one that can now be repeated with confidence, while the ambisonic approach is positioned for further development but in surround or binaural formats. Best equipment and techniques have been identified and the methodology refined through testing equipment in flight to deliver the best results.

Flight 1 was hampered by payload spinning but did function as a test for an untried recording method and also provided strong outcomes at high altitudes. Flight 2 saw the methodology refined with solid outcomes and developments, providing a better investigation of the stratosphere and introducing the notion of aerial phonography, given the soundscape on the day I feel flight 2 is the better sound recording of all flights. Flight 3 successfully progressed to 360 footage

with stereo sound and laid a platform for methodology to be refined in Virtual Reality formats, while also providing sound and footage of commercial aeroplanes flying at cruising altitude and speed.

An important development to emerge from the methodology is the aforementioned notion aerial phonography and recording soundscapes from above. This will allow for future practice in an investigation of recording soundscapes from above as opposed to the usual within. Methods will include balloons tethered to the ground to place stationary microphones in the sky, recording from atop of large buildings, or from cliff tops to listen down in to the valley.

However, it is still not clear whether microphones have in fact been placed away from all sound with nothing to excite the diaphragms and a silent environment recorded, or whether the environment high in the stratosphere is in fact quieter than locations in the desert of far western NSW. On peeling back the noise floor in postproduction, it is thought the lower frequency sounds of wind at high altitudes can be heard, but only after detailed noise reduction and extreme playback volume. But at this peak of quietude just before burst point, the line between system noise and the sound of wind is blurred to a point of uncertainty. It is unknown if winds in the jet stream and stratosphere make audible sound without surfaces or obstacles to blow around, making the precise source of any sound still undetermined. A mechanical ear has successfully been placed in the sky and the recording system taken to its limit, the recordings approximately tell us what it might sound like if it were possible to place our own ear in the stratosphere. Nonetheless, the gradual decrease in amplitude of the sonic environment to only a slight presence of system noise at the highest altitudes shows the extreme quietude of the stratosphere and is a significant step to escaping all sound and recording a natural silence.

Final Conclusions.

This research is a creative practice-based pursuit that also lays the foundation for further research in each of the areas examined. In concluding I will briefly summarise the outcomes and possibilities for further research. The initial key questions of the research were:

1. Is it possible to record rooms in a state of placidity and use these room tone recordings as the basis for composition?
2. If we peel back the sound layers of our environments, what is the fundamental sonic substructure of our soundscapes ranging from the home, to the city, and remote natural place?
3. Is it possible to place microphones away from all sound in the stratosphere?

Sound recording and composition were used to peel back sound layers and explore the often hidden sonic substructure of our soundscapes, followed by an eventual escape from all sound in the stratosphere. A recording approach that seeks to avoid primary sounds taken from room tone recording in film production was used to record near silent environments with a view to using the resulting recordings for composition, and to document the progression towards recording a sonic silence. A minimal approach to sound processing and composition was used to maintain authenticity to the field-recordings, but also continue a theme of reduction in composition by limiting this to amplitude, equalisation, length, and placement. This was to ensure sound recordings were not overly altered and to avoid any reliance on extreme sound processing.

The research progression moved outwardly from: a single room, to a house, to the city, to the desert, then to the stratosphere. An overriding question in the research asks, is it possible to place microphones away from all sound and record a naturally silent environment? Through the sound recording practice it was found that anthrophony and biophony are escapable but the geophony of wind is a constant fundamental sonic substructure. The sound of a room may be

reduced to its fundamental resonance; the sounds of people in cities may be reduced to building drone through a pandemic; the sounds of human infrastructure may be removed through remote location; the sounds of wildlife and vegetation may be reduced through barren landscapes; or all of the above may be removed through altitude. However, throughout all recording within this research the geophony of wind is constant - a fundamental in any soundscape, and the lowest-level sound layer within the human hearing range. Even at altitudes of 33km, stratospheric winds are the only sounds heard between those of distant airplanes 20 kilometres below.

Moving through the chapters: the first chapter begins the progression by peeling back the sound layers of a house, the noise of film production was removed to examine an empty house through room tone recording and composition. This was primarily a creative pursuit and an alternate approach to electroacoustic composition with the research seeking to:

- record the unique sonic personalities of rooms without triggering resonance.
- use the resulting room tone recordings as sonic objects for composition.

Postproduction and composition showed the sonic substructure, or personality, of a near-silent room is made up of the surrounding external sound environment. In areas of the recordings free of primary sound, the base-level sound required to sonically illuminate the room is not specifically identifiable but, rather, heard as a low din made up of distant sounds. Sound is always present in an everyday room and in this house, at this time, it was primarily a low-level distant anthrophony, an example of the common fundamental sound of urban homes. The composition process showed that composing with room tone recordings within such strict limitations was difficult, further exacerbated by the high presence of system noise in recording such low-level sound. The recordings sound similar; identifying and removing noise without affecting the recorded environment in postproduction was difficult with the line between system noise and the recorded environment often blurred. In the recordings used here, details

were captured and system noise reduced sufficiently to assist in isolating the sound of the room. However, in order to hear the differences between the rooms for composition, each room's tone needed to be equalised to emphasise and explore its individual sonic characteristics. The first methodology used in *Gradualism* and *Rapidity* saw a room separated into frequency bands then put together in an altered state using samples that increase in length and occurrence to sonically explore the room. Following this, the key question of how to compose with silent rooms was explored in *Walking around an Empty House* where room tone recordings were used to reinterpret the idea of continuously walking around an empty house in different directions. To make composition possible, equalisation was needed on the four different room recordings to accentuate their sonic differences by focusing on any distinguishable frequency traits. Although these traits are subjectively enhanced in composition and it was hoped this could be avoided entirely, the difference between the rooms is audible and the concept of composition with different room tones was achieved. First and foremost, these compositional studies are experiments that explore the sound of empty rooms; the limitations put in place for composition to maintain authenticity to the recordings was a methodological and conceptual challenge that made the creative task more demanding.

The contribution to the field of electroacoustic composition here is a creative investigation and an alternate use of room tone recording in musical composition. It is an original approach to composition with the sound of interior environments that does not rely or focus on manually-triggered resonance and the resulting phenomena, and attempts to capture and explore the room in a truly near-silent state. Further research in this area would see the same approaches to recording, however there is scope for further work with different microphones of less noise and different formats of spatial audio (binaural and surround) in recording, mixing and playback. Additionally, exploring interiors of varied acoustic properties outside of a standard house, for example: a cathedral, caves, the unused St. James subway in Sydney, or the empty Inchindown World War 2 oil storage tanks in Scotland are examples of possibilities for alternate interior locations. The use of similar reductional methods in composition are

also open to further investigation, not just based on near silent recordings but those of louder content, or instruments such as electric guitar. This practice-based approach also lays the foundation for further research that examines our interior soundscapes and how we experience these, working from the lowest levels of near-silent rooms up to louder work environments, shopping centres, or restaurants for instance.

In Chapter 2, the room tone recording approach is taken to exterior locations. The Covid-19 pandemic provided an opportunity in the progression to peel back sound layers by using the lockdown to listen below the primary sounds of a city and record the Sydney CBD in a unique state of quietude, or the room tone of the CBD. This was a practice-based investigation through sound recording and composition that captures and analyses soundscape data, but it does not claim to be a detailed soundscape research. It partially answers the questions:

- What would it sound like if we could remove people from the city?
- What would be the impact of Covid-19 lockdowns on the city soundscape?

With the people gone, other sounds were heard in detail. Building drone of the city was revealed as the significant unavoidable sonic substructure, with the fundamental city geophony of leaves being blown across the ground or water lapping at the harbour shore also revealed in greater detail. These findings are summarised in *Reinterpretation of the Covid-19 Sydney CBD soundscape*. The impact of lockdown on the education sector was creatively represented in *Reinterpretation of UTS Building 10*, which presents recordings of a university building in lockdown. With the students absent, the creaks and cracks of the building heating as the sun comes out are heard, along with the gentle drones of the building.

The contribution to research is a detailed, sonic documentation of the Sydney CBD during the 2020 Covid-19 lockdowns. Further comparison recordings would provide a better understanding of the quietude of the 2020 Covid-19 lockdown, and is an option for further research. Sound-level data of

Sydney's pre-Covid-19 city soundscape would also be beneficial along with data on, for instance, public transport function, traffic, tourism both pre, during, and post-Covid-19.

In Chapter 3, to remove all anthrophony and biophony, locations were selected in a remote and barren region in the Australian desert in far western New South Wales. Here, progressing from Bourke towards White Cliffs, this researcher found the quietest location on the ground within this project. The recording of the final location contains areas of almost exclusively system noise; while on location nothing could be heard when straining to hear any sound, except my low-level high-pitched tinnitus. Given the time of year, geographic details, remoteness, the recording gathered and the subjective experience of being there, I hypothesise this must be one of the quietest possible locations in the natural world. There is no anthrophony or biophony and the natural soundscape is reduced to the lowest level of the sonic substructure; the geophony of surrounding winds blowing across the landscape. This is the ancient and increasingly rare sound on the ground that was the recording target, a now very rare occurrence that excludes all sounds of life. Composition here again summarises the findings and focuses on a near-silent sunset in the desert reinterpreted into a short study using the quietest location found in the day and a night recording that captures the sonic substructure of gentle winds. With these conclusions - similarly to those of chapter one - further recording with sound equipment of less self-noise, different microphone directionalities and techniques, and recording in different locations of remote desert or heavy snow, would add to a continuing sonic examination of remote areas and rare, near-silent, ancient soundscapes. There is also the potential to progress to including infrasound to gain a better understanding of the lowest-level sound layers of the natural soundscape.

In a step to escape all sound, the final chapter saw weather balloons incorporated in my recording methodology to record the stratosphere, showing that even at altitudes above 30km the anthrophony of aeroplanes can still be heard, as can the geophony of stratospheric winds. The weather balloon

recording methodology is a novel field-recording technique to achieve high-quality recordings through the troposphere and up to the stratosphere in the progression towards a sonic silence. The design of the recording system and housing for the equipment was refined to capture the best recording. Flight 2 contains the first and best example of the notion of sonic height perspective in this research and begins the notion of recording soundscapes from above; this flight also reached the closest to a sonic silence in this research. Flight 3 extends the recording methodology to capture 360-degree footage to accompany the stereo sound recording, suggesting the possibility of further investigation in virtual-reality formats.

Was silence located and recorded in the stratosphere? Stratospheric winds are heard occasionally gently blowing by the payload and it was concluded there is a continuous sonic presence caused by winds. However, it is unclear whether the winds below in the troposphere make sound with nothing to blow by and around and whether this sound propagates up to the stratosphere. Or is the sonic presence simply derived from surrounding far-off airplanes? However, given the findings in sonic height perspective and the upward propagation of sound, is it actually possible for anthrophony to propagate from the ground and into the stratosphere as a low-level din?

The contribution here was a novel sound-recording technique and, believed to be, the only sound-centric, high-quality sound recording of a weather balloon flight to the stratosphere. The methodology leads to areas of further research in sonic height perspective and aerial phonography: investigating the use of tethered balloons with a small recording system as a methodology to record and listen to soundscapes from above. What does aerial phonography tell us and what can aerial phonography tell us? The recording methodology can also be developed to further streamline the payload and use surround-sound microphone arrays for future flights. The methodology also promotes the use of practice-based research to sonically explore other worlds. To not rely on modelling to hypothesise what soundscapes might consist of, or use other instruments to capture data that misrepresents the true sonic qualities of an

unexplored soundscape, instead sound practitioners might develop robust techniques to accurately record other worlds using rovers such as the Mars Perseverance rover. The soundscape of the moon maybe silent but is it not of interest to accurately record this soundscape?

This research has been a practice-based investigation of sound recording, composition and the lowest level of our soundscapes. Novel field-recording practices have been developed to capture the lowest-level sound layers in a progression to a sonic silence within the human hearing range, and original approaches to composition with field recordings have been developed and explored to creatively summarise the recording findings. The research also leads the way for further detailed soundscape research in each area and the possibility of further investigation.

References.

Artlyst 2014, *Piet Mondrian Neo Plasticism And Urban Spacial Relationships Tate Liverpool*, website, Artlyst Ltd. Liverpool UK, viewed 7 October 2020, <https://www.artlyst.com/reviews/piet-mondrian-neo-plasticism-and-urban-spacial-relationships-tate-liverpool/>

Atkinson, N. 2020, *Perseverance Microphones Fulfill Planetary Society Campaign to Hear Sounds from Mars*, United States, viewed 22 July 2020, <https://www.planetary.org/articles/perseverance-rover-tps-mics>

Avci, Z. 2015, 'Atmospheric Conditions', *Civil Aviation Environmental Protection*, weblog, viewed 28 June 2018, <http://groupfourthavm.blogspot.com/201 5/05/zeynep-avci.html>

Bakare, L. 2020, 'Art project captures sound of cities during coronavirus outbreak', *The Guardian*, 1 April, viewed 2 April 2020, <https://www.theguardian.com/world/2020/mar/31/art-project-captures-sound-of-cities-during-coronavirus-outbreak#maincontent>

Batchelor, P. 2013, 'Lowercase Strategies in Public Sound Art: celebrating the transient audience', Organised Sound, Vol. 18, pp. 14 – 21.

Bencina, R. 2021, *AudioMulch*, website, viewed 23 August 2021, <http://www.audiomulch.com/>

Blesser, B & Salter, L. 2006, *Spaces Speak, are you listening?*, The MIT Press, Cambridge.

Bourke to White Cliffs 2021, Google Maps, viewed 10 June 2020, <https://www.google.com/maps/d/edit?hl=en&hl=en&mid=1D-keDJl7aFokmeu_GTDKP8UVKAc4mcsV&ll=-30.219125749425324%2C144.2627160550781&z=9>

Brophy, P. 1997, 'Booms, Drones & Other Dark Waves - Lost Highway', Real Time No.18, Sydney.

Bowman, D., Young, E., Krishnamoorthy, S., Lees, J., Albert, S., Komjathy, A. & Cutts, J. 2018, *Geophysical and Planetary Acoustics via Balloon Borne Platforms*, U.S. Department of Energy Office of Scientific and Technical Information, Sandia National Lab, United States.

Bui, Q. & Badger, E. 2020, 'The Coronavirus Quieted City Noise. Listen to What's Left', *New York Times [The Upshot]*, 22 May, viewed 22 May 2020, <https://www.nytimes.com/interactive/2020/05/22/upshot/coronavirus-quiet-city-noise.html>

Bureau of Meteorology 2018, *Balloon-based Weather Observations*, Australia, viewed 31 January 2019, <http://www.bom.gov.au/faq/pdf/Balloon-basedWeatherObservations_FactSheet_SEPT18.pdf>

Bureau of Meteorology 2020, *Interactive Weather and Wave Forecast Maps*, Australia, viewed 30th January 2020, <http://www.bom.gov.au/australia/charts/viewer/index.shtml?type=windbarb&level=200hPa&tz=AEDT&area=Au&model=CG&chartSubmit=Refresh+View>

Candy, L. 2006, 'Practice Based Research: A Guide', *Creativity and Cognition Studios*, viewed 14 March 2017, <https://www.creativityandcognition.com/wp-content/uploads/2011/04/PBR-Guide-1.1-2006.pdf>

Cabrera, Densil. 1997, *Resonating Sound Art and the Aesthetics of Room Resonance*, Convergence, Vol. 3, No. 4, pp 108-137.

Cage, J. 1968, *Silence: Lectures and Writings*, Calder and Boyars, London.

Challeat, S., Farrugia, N., Froidevaux, J., Gasc, A. 2020, 'Silent Cities: a participatory programme of an exceptional modification of urban soundscapes'. 25 March 2020, call for participation in data collection, viewed 20 April 2020.

Circular Quay Sydney 2021, Google Maps, viewed 22 May 2020, <https://www.google.com/maps/place/Circular+Quay,+Sydney+NSW+2000,+Australia/@-33.8611191,151.2081021,16z/data=!4m5!3m4!1s0x6b12ae69d26aafad:0x7f9b21ebd5b57ce0!8m2!3d-33.8611374!4d151.2126457>

Cities and Memories 2020, *Sounds from the global Covid-19 lockdown*, Oxford, viewed 2 April 2020, <https://citiesandmemory.com/covid19-sounds/>

City of Amsterdam. 2021, *Secrets of Amsterdam's oldest building*, website, viewed March 8 2021, <https://www.amsterdam.nl/nieuws/achtergrond/geheimen-amsterdams-oudste-gebouw/?fbclid=IwAR0y15qq-JVHyc24SlVd1NapL09nzIe4LQwSY2HDPG7MxRMWDl4wG8HrTq8>

Civil Aviation Safety Authority. 2003, *Civil Aviation Safety Regulations PART 101 Unmanned aircraft and rocket operations 1st Edition – January 2003*,

Collins, S. 2019, *Inside David Lynch's Scariest Scene*, viewed 25 August 2022, <https://theoutline.com/post/7272/lost-highway-mystery-man-robert-blake-david-lynch>

Conversations with Richard Fidler 2017, radio program, ABC RN, Sydney, 23 October.

Cox, C. 2009, *Sound Art and the Sonic Unconscious*, Organised Sound, vol.14, pp. 19-26.

Crawford, C. 2011, 'The Sounds of the Universe', *Gresham College*, London, viewed 15 December 2016, <https://www.gresham.ac.uk/lectures-and-events/the-sounds-of-the-universe>

Crawford, D. 2013, 'The Sound of One Ant Walking – inside the world of a wildlife audio expert', *Radio Times,* viewed 10 June 2016, <https://www.radiotimes.com/news/2013-02-19/the-sound-of-one-ant-walking-inside-the-world-of-a-wildlife-audio-expert/>

Dallinga, M. 2020, 'The sounds of a pandemic: Amsterdam sounds like Nijkerk', *NRC*, 16 April, viewed 19 April 2020, <https://www.nrc.nl/nieuws/2020/04/16/hoe-een-pandemie-klinkt-a3996836>

DPA Microphones. 2021, 'Exploring the sounds of Mars with DPA', viewed 17 August 2021, <https://www.dpamicrophones.com/mars-rover?utm_medium=post&utm_source=facebook&utm_campaign=social-media&utm_content=mars-90-foot-drive-1&fbclid=IwAR1KnAWtVlnuYic0V14sl4iy8v3e3y-4mB6HfiC1EjqpEaO1BN1QQpqJdX0>

Extreme. 1998, *Otomo Yoshihide & Sachiko M. – filament 1*, CD catalogue, viewed 7 May 2021, <http://extrememusic.com.au/catalog/XCD-045/>

Fallazadeh, A. & G, Yousof. 2019, 'Piet Mondrian, early Neo-Plastic compositions, and six principles of Neo-Plasticism', Rupkatha Journal on Interdisciplinary Studies in Humanities, Vol. 2, No. 3, pp. 1-18.

FEL Communications. 2021, *Clippy XLR EM272, Matched Stereo Pair*, website, viewed 28 September 2021, <https://micbooster.com/gb/clippy-and-pluggy-microphones/99-xlr-stereo-clippy-em272-microphone.html>

Figgis, M. 1998, 'Silence: The Absence of Sound', *The School of Sound Lectures, 1998 – 2001*, The School of Sound, London, pp. 1-14.

Fischer, T. 2012, 'Interview with Francisco López', *Tokafi*, 2012, viewed 27 August 2021, <http://www.tokafi.com/15questions/interview-francisco-lopez/>

Freeman, P. 2000, Bernhard Guenter: The Rewards of Concentration, website, viewed 25 August 2002, <https://www.furious.com/perfect/guenter.html>

GoPro. 2019, *Hot and Cold Operating Temperatures for the HD HERO Original,* viewed 10 January 2019, <https://gopro.com/help/articles/question_answer/Hot-and-Cold-Operating-Temperatures-for-the-HD-HERO-Original>

Green. D, 2020, *Do Those Birds Sound Louder To You? An Ornithologist Says You're Just Hearing Things*, audio podcast, American University Radio, Washington, 6 May, viewed 10 June, <https://wamu.org/story/20/05/06/do-those-birds-sound-louder-to-you-an-ornithologist-says-youre-just-hearing-things/>

Grundy, D. 2012, 'Listening to Sachiko M', *Eartrip Magazine*, 5 April, viewed 5 May 2021, <https://eartripmagazine.wordpress.com/articles/articles-issue-7/listening-to-sachiko-m/>

Gunter, B. 1993, *Un Peu De Neige Salie*, Selektion, Germany.

Hanford, A. & Long, L. 2006, 'Computer Simulations of the Propagation of Sound on Mars', paper presented to the 151st ASA Meeting, Providence RI, 6 June.

Hanford, A. & Long, L. 2009, 'The Direct Simulation of Acoustics on Earth, Mars and Titan.', *Journal of the Acoustical Society of America*, vol. 125, no.2, pp. 640-650.

Haines, D & Hinterding, J. 2017, *Soundship (descender 1)*, viewed April 2017, <http://www.haineshinterding.net/2017/03/28/soundship-descender-1/>

Hainge, G. 2004, 'The Sound of Time is not 'tick tock': The Loop as a Direct Image of Time in Noto's "Endless Loop Edition (2)" and the Drone Music of Phill Niblock', *InVisible Culture: An Electronic Journal for Visual Culture*, issue 8, viewed 8 March 2021, < https://ivc.lib.rochester.edu/the-sound-of-time-is-not-tick-tock-the-loop-as-a-direct-image-of-time-in-notos-endless-loop-edition-2-and-the-drone-music-of-phill-niblock/>

Hedges, D. 2015, *The Use Of Swivels In High Altitude Ballooning*, viewed January 2018, <https://www.youtube.com/watch?v=FFO6r-_SrYM>

Hess, F. 2001, *Air Pressure Fluctuations*, album, Edition RZ, Germany.

High Altitude Science 2019, *Intro to Weather Balloons*, viewed 31 March 2019, <https://www.highaltitudescience.com/pages/intro-to-weather-balloons>

Hinkson, M. 2001, *Aboriginal Sydney: a guide to important places of the past and present*, Aboriginal Studies Press for the Australian Institute of Aboriginal and Torres Strait Islander Studies, Canberra.

Hofer, S. 2014, ‘‘Atomic’ Music: Navigating experimental electronica and sound art through microsound’, Organised Sound, Vol. 19, pp. 295 – 303.

Ingard, U. 1953, ‘A Review of the Influence of Meteorological Conditions on Sound Propagation’, *The Journal of the Acoustical Society of America*, Vol. 25, no. 3, pp. 405-411.

iZotope. 2021a, *Spectral De-noise [STD & ADV]*, user manual website, viewed 28 September 2021, <http://downloads.izotope.com/docs/rx6/34-spectral-de-noise/index.html>

iZotope. 2021b, *Spectral De-noise*, website, viewed 28 September 2021, <https://www.izotope.com/en/products/rx/features/spectral-de-noise.html>

JaME. 2009, *Interview with Sachiko M*, weblog, viewed 5 May 2021, <https://www.jame-world.com/en/article/75889-interview-with-sachiko-m.html>

Jepsen, M. 2017, ‘Low-frequency sea sounds ring clear at high altitudes’, weblog, GeoSpace, viewed 23 November 2018, <https://blogs.agu.org/geospace/2017/08/31/low-frequency-sea-sounds-ring-clear-at-high-altitudes/>

Keep, S. 2007, ‘Aerial Phonography’, weblog, viewed 10 January 2019, <http://holkham.blogspot.com/2007/02/project-outline-when-you-listen-to.html>

Kennedy, M. 2001, ‘CD art and the sound of silence’, *The Guardian*, viewed 25 August 2022, <https://www.theguardian.com/uk/2001/nov/09/maevkennedy?CMP=gu_com>

Kenotaphion. n.d., *Kenotaphion*, website, viewed 25 August 2022, < https://kenotaphion.org/>

Kirkegaard, J. 2006, *4 Rooms*, album, Touch, United Kingdom.

Kirkegaard, J. 2017, *Fonik*, website, viewed 5 August 2017, <http://fonik.dk/works/4rooms.html>

Kostelanetz, R. 2003, *Conversing with Cage*, Abingdon, Oxon: Routledge, United States

Krause, B. 2012, *The Great Animal Orchestra*, Hachette Book Group, New York.

La Casa, E and Guionnet, J. 2014, *Home: Handover*, Potlatch, France.

Lectrosonics. 2021, *SPDR Stereo Portable Digital Recorder*, website, viewed 28 September 2021, <https://www.lectrosonics.com/SPDR-Stereo-Personal-Digital-Recorder/product.html>

Leighton, T and Petculescu, I. 2008, 'Sounds in Space: the potential uses for acoustics in the exploration of other worlds', *Hydroacoustics*, Volume 11, 225-238.

Lessard, B and Yeates, D. 2016, 'From warm to swarm: why insect activity increases in summer', *Australian Geographic*, 1 December, viewed 25 August 2021,<https://www.australiangeographic.com.au/topics/science-environment/2016/12/experts-predict-increased-insect-activity-this-summer/>

Lopez, F. 1995, *Warszawa Restaurant*, album, Trente Oiseaux, Germany.

Lopez, F. 1998, *La Selva*, album, V2_Archief, Netherlands.

Lopez, F. 2001, *Buildings [New York]*, musical composition, V2_Archief, Netherlands

Lopez, F. 2007, *Wind [Patagonia]*, album, And/OAR, US.

Lopez, F. 1998, *Environmental Sound Matter*, viewed 10 March 2016, <http://www.franciscolopez.net/env.html>

Loubet, E. 2000, 'Laptop Performers, Compact Disc Designers, and No-Beat Techno Artists in Japan: Music from Nowhere', Computer Music Journal, Vol. 24, No. 4, pp. 19–32.

Lucier, A. 1980, *I am sitting in a room…*, musical composition, Lovely Music, Ltd., United States.

Lucier, A. 1979, 'Careful Listening is More Important than Making Sounds Happen', in C. Kelly (ed.), *Sound*, Whitechapel Gallery, London, pp. 112-116.

Lucier, A & Simon, D. 1980, *Chambers*. Wesleyan: Wesleyan University Press.

Lynch, D. 1977, *Eraserhead*, motion picture, Libra Films, US.

Lynch, D. 1997, *Lost Highway*, motion picture, CiBy 2000, US.

Mark, D. 2020, 'Australia is facing a "once-in-a-lifetime opportunity" as cycling booms, advocates say', *ABC News*, 17 May, viewed 22 May 2020, < https://www.abc.net.au/news/2020-05-17/coronavirus-brings-once-in-a-lifetime-opportunity-for-cycling/12247870>

Martin, R. 2021, 'Microphones On NASA's Rover Will Record Audible Sounds On Mars', radio program, NPR, February 11, viewed 10 August 2021, <https://www.npr.org/transcripts/966757175?fbclid=IwAR0rffYqOSj7fX9H38MQeET59Kg5KUbxBRPNsMlqop2oNiPGL0zKoUN1_7A&t=1615540904491>

Mashable, 2018. *How NASA recorded the eerie Martian wind, without a microphone*, viewed 12 December 2018, <https://mashable.com/article/mars-sound-wind-recording-insight-lander/>

Matsubara, S. 2004, *Bar Sachiko*, album, Improvised music from Japan, Japan.

Matsubara, S. 2007, *Salon de Sachiko*, album, Hitorri, Japan.

Matsubara, S & Yoshihide, O. 1998, *Filament 1*, album, Extreme, Australia.

Matsubara, S & Sakamoto, R. 2012, *Sachiko M + Ryuichi Sakamoto – Snow, Silence, Partially Sunny*, album, Commmons, Japan.

McCrory, S. 2020, 'Slow Down With Norway's Slow TV', *Scandinavia Standard*, 26 May, viewed 3 October, <https://www.scandinaviastandard.com/slow-down-with-norways-slow-tv/>

Merzbow. 2002, *A Taste Of...*, album, Mego, Austria.

Michael, D. 2011, 'Towards a Dark Nature Recording', Organised Sound, vol. 16, pp. 206-210.

Mondrian, P. 1915, *Composition 10 Pier and Ocean*, Kroller Muller Museum, Otterlo, viewed October 2020, oil on canvas.

Mondrian, P. 1926, 'General Principles of Neo Plasticism', essay, Paris.

NASA. 2017, *Scientific Balloons FAQs*, United States, viewed 15 January 2019, <https://www.nasa.gov/scientificballoons/faqs>

NASA. 2019, *Microphones on Mars 2020*, United States, viewed 16 June 2017, <https://mars.nasa.gov/mars2020/mission/rover/microphones/#SuperCam-Microphone>

NASA. 2021, *Mars 2020 Mission Perseverance Rover Sounds of Mars*, viewed 16 August 2021, <https://mars.nasa.gov/mars2020/participate/sounds/?playlist=mars&item=mars-helicopter-flying&type=mars>

NASA Jet Propulsion Laboratory. 2021, *Another First: Perseverance Captures the Sounds of Driving on Mars*, viewed 18 March 2021, <https://www.jpl.nasa.gov/news/another-first-perseverance-captures-the-sounds-of-driving-on-mars?fbclid=IwAR21dUaWlNADF8o_axHcgLk0m6LvW4qH6wJTfA_4Bps5OzM21ynAJ8L0_Xc>

New York University, 2020, *Sounds of New York City*, New York University, viewed 22 May, <https://wp.nyu.edu/sonyc/>

Novak, D. 2010, 'Playing Off Site: The Untranslation of Onkyô', Asian Music, vol. 41 no. 1, 2010, pp. 36-59.

One Square Inch. 2021, *One Square Inch*, viewed 15 February 2016, <http://onesquareinch.org/>

Open Acoustic Devices. 2020, *AudioMoth*, website, viewed May 5 2020, <https://www.openacousticdevices.info/audiomoth>

Park, R. 1973, *The Companion Guide to Sydney*, William Collins, Australia.

Parks Canada 2021, *Grasslands National Park*, viewed April 2016, <https://www.pc.gc.ca/en/pn-np/sk/grasslands/nature>

Phys Org. 2006, *Can you hear me now? Not on Mars*, viewed 15 November 2018, <https://phys.org/news/2006-06-mars.html>

Pijanowski, B.C., Villanueva-Rivera, L.J., Dumyahn, S.L., Farina, A., Krause, B., Napoletano, B.M., Gage, S.H., Pieretti, N. 2011, 'Soundscape Ecology: The Science of Sound in the Landscape', *Bio Science*, vol. 61, no. 3, pp. 203–216.

Place and Sound 2013, radio program, ABC RN, Sydney, 26 October.

Pousseur, H. 1957, *Scambi*, composition, Electronic-Music Studio of the NWDR, Cologne.

Prochnik, G. 2010, *In Pursuit of Silence Listening for Meaning in a World of Noise*, Double Day, New York.

Project Horus. 2016, *Project Horus High Altitude Balloon Project*, Australia, viewed 5 September 2018 <http://www.projecthorus.org/>

Redhouse, N. 2020, 'Quiet Life', *The Monthly*, May, viewed 8 June, <https://www.themonthly.com.au/issue/2020/may/1588255200/nicola-redhouse/quiet-life#mtr>

Railway Square Sydney 2021, Google Maps, viewed 22 May 2020, <https://www.google.com/maps/search/Railway+square+sydney/@-33.8837149,151.2017575,17z/data=!3m1!4b1>

Rembert, V. 2016, *Piet Mondrian*, Parkstone Press International, New York.

Rhizme 2002, *Singing Bridges*, New York, viewed 10 September 2016, <http://rhizome.org/art/artbase/artwork/singing-bridges/>

Richardson, J. 2014, 'Exploring the unheard: A phenomenological listening experience with 'Air Pressure Fluctuations' by Felix Hess', *Orema*, Viewed 25 August 2022, <http://orema.dmu.ac.uk/eorema/exploring-unheard-phenomenological-listening-experience-%E2%80%98air-pressure-fluctuations%E2%80%99-felix>

Rode Microphones. 2021, *NT-FS1 Soundfield by Rode*, website, viewed 15 July 2019, <https://en.rode.com/ntsf1>

Rogers, H; Vernallis, C; Perott, L. 2020, *Transmedia Directors: Artistry, Industry and New Audiovisual Aesthetics*, Bloomsbury Publishing, US.

Rose, J. 2004, *Singing Bridges Vibrations: Variations*, album, Sonic Artstar, Australia.

Rubinstein, D. 2012, 'The Sounds of Silence', *Canadian Geographic*, April, pp. 40-50.

Sanken Microphones. 2021, *COS-11D lavalier high-definition mics*, website, viewed 28 September 2021, <https://www.sankenmicrophones.com/production/lavalier/cos-11d/>

Saunders, J. 2009, *The Ashgate Research Companion to Experimental Music*, Ashgate.

Schaefer, J. 2016, *Audioh*, website, viewed 5 August 2016, <http://www.audioh.com/projects/vacantspace.html>

Schaeffer, P. 1948, *Etude aux Chemins de Fer*, musical composition, RTF, Paris.

Schaeffer, P. 2012. *In Search of a Concrete Music*, University of California Press, Berkeley.

Schaeffer, P. 2017, *Treatise on Musical Objects : An Essay Across Disciplines*, University of California Press, California

Schafer, R.M. 1977, *The Soundscape: our sonic environment and the tuning of the world*, Destiny Books, Vermont.

Seeker VR 2016, *Journey to the Edge of Space (360 Video)*, video recording, YouTube, viewed 16 August 2021, <https://www.youtube.com/watch?v=pCve1w1GFOs>

Seismological Society of America. 2017, *High-flying experiments demonstrate potential of balloon-borne infrasound detection*, Phys Org, United States, viewed 15 January 2019, <https://phys.org/news/2017-04-high-flying-potential-balloon-borne-infrasound.html>

Semper, J. 2001, *Kenotaphion*, album, Charrm, United Kingdom.

Sidelnikova , Y. 2021, Broadway Boogie Woogie, website, viewed 7 May 2021, <https://arthive.com/pietmondrian/works/262900~Broadway_boogie_woogie>

Snijders, T. 2020, '"The city is ours again": How the pandemic relieved Amsterdam of overtourism', *The Washington Post*, 7 May, viewed 8 May 2020, <https://www.washingtonpost.com/travel/2020/05/06/city-is-ours-again-how-pandemic-relieved-amsterdam-overtourism/>

Solomos, M. 2019, 'A phenomenological experience of sound. Notes on Francisco López', Contemporary Music Review, vol. 38 no. 1-2, 2019, pp. 94-106.

Sounds of a City 2020, short film, Dayne Hudson, Sydney, <https://www.daynehudson.com/work/soundsofacity>

Sound Devices. 2021, *Sound Devices 788T-SSD*, website, viewed 27 August 2021, <https://www.sounddevices.com/product/788t-ssd/>

St James Station Sydney 2021, Google Maps, viewed 22 May 2020, <https://www.google.com/maps/place/St+James+Station/@-33.8700595,151.2032975,15z/data=!4m5!3m4!1s0x6b12ae15386aec71:0xcd6f2266d9bb562b!8m2!3d-33.8707076!4d151.2104429>

Steele, D. & Guastavino, C. 2021, 'Quieted City Sounds during the COVID-19 Pandemic in Montreal', *International Journal of Environmental Research and Public Health*, Vol. 18, No. 11, article 5877.

Steinke, Nicole. 2013, 'Place and Sound', *Into the Music*, radio program, ABC Radio National, 26 October, viewed 26 October 2016, <https://www.abc.net.au/radionational/programs/archived/intothemusic/place-and-sound/4999640>

The Writing and Society Research Centre 2016, *What Where Film By Samuel Beckett - Film and Documentary* 2013, film and documentary, viewed 20 August 2021, <https://www.youtube.com/watch?v=nMi1fUZO454>

Traa, A. 2020a, 'City Residents Reclaiming Public Space', *The Auditory Service*, weblog, Amsterdam, viewed 30 April 2020, <https://deauditievedienst.tumblr.com/post/616552903984955392/city-residents-reclaiming-public-space>

Traa, A. 2020b, 'Corona Comparison - Oude Kerk 2015-2020', *The Auditory Service*, weblog, Amsterdam, viewed 5 April 2020, <https://deauditievedienst.tumblr.com/?fbclid=IwAR33VVpkQkwOczLztN-lkPQ0FEpuko-aSNeEIxzNE0hMUizHkemW7-0Xyoo>

Traa, A. 2020c, 'Corona recordings Amsterdam Corona: Comparisons 2012 – 2020', sound recording, Soundcloud, viewed 10 April2020 , <https://soundcloud.com/de-auditieve-dienst/sets/corona-recordings-amsterdam-de-dam-comparison-2012-2020>

V101 Science. 2020, *This Is What The Surface Of Venus Sounds Like! Venera 14 Sound Recording 1982*, video recording, YouTube, viewed 20 March 2018, <https://www.youtube.com/watch?v=P3Ife6iBdsU>

Viers, R. 2008, *The Sound Effects Bible: how to create and record Hollywood style sound effects*, Michael Wise, California.

Vitiello, S. 1999/2000, *World Trade Centre Recordings: Winds After Hurricane Floyd*, installation, Whitney Museum of American Art, New York, viewed 5 June 2020, < https://whitney.org/collection/works/15832>.

Voegelin, S. 2010, Listening to Noise and Silence: Towards a Philosophy of Sound Art, Bloomsbury Academic & Professional, New York.

Watson, C. 1998, *Outside the Circle of Fire*, album, Touch, UK

Watson, C. 2003, *Weather Report*, album, Touch, UK

Watson, Chris. 2017, *Environmental Sound Recording Masterclass with Chris Watson*, Wired Lab, Mount Kosciusko National Park.

Waves Audio. 2021, *WNS Noise Suppressor*, website, viewed 28 September 2021, <https://www.waves.com/plugins/wns-noise-suppressor>

Weaver, R & McAndrew, J. 1995, *The Roswell Report Fact Versus Fiction in the New Mexico Desert*, Headquarters United States Airforce, U.S Government Printing, Washington DC.

Yoshihide, O. 2014, *Otomo Yoshihide Official Site*, website, viewed 5 May 2021, <http://otomoyoshihide.com/en/?page_id=4>

Xiaomi. 2019, *Mi Sphere Camera Kit,* viewed 10 January 2019, <https://www.mi.com/us/mj-panorama-camera/specs/>

Young, G. 2008, 'Building Sound from the Ground Up Hugh Le Caine: Designer of Instruments for Electronic Music', *Literature and Arts of the Americas, Issue 76, Vol. 41, No. 1, 2008,* pp. 158-163.

Zoom Corporation. 2014, *Zoom H4next Handy Recorder Operation Manual,* Zoom Corporation, Tokyo.

Zoom Corporation. 2021, *Zoom H6 Black*, website, viewed 20 December 2017, <https://zoomcorp.com/en/us/handheld-recorders/handheld-recorders/h6-audio-recorder/>

Appendices.

1. Covid-19 Sydney CBD Sound Recording Analysis.

See submitted sound recording library:

2.1 Covid-19 Sydney CBD Location Sound Recordings

2.1.1_Opera Bar (56dB SPL A)

The Opera Bar was recorded on Sunday the 29th March 2020, while the Opera House Promenade on Easter Monday the 13th April 2020. At the Opera Bar microphones were placed on the sea wall to capture a general atmospheric harbour recording. Harbour traffic appears greatly diminished, in the recording singular passing boats are heard, birdcall is clear, water laps against the harbour wall, conversations of the few passers-by are captured from a distance, while distant traffic on the Harbour Bridge is now heard as a subtle din that combines with the drone of surrounding buildings to form a bed of anthrophony.

Figure 59: the Opera Bar sees greatly reduced foot traffic.

Figure 60: microphones on the harbour wall.

2.1.2_Opera House promenade (53dB SPL A)

On the Opera House promenade the microphones are set on the handlebars of the bicycle to avoid detection and closer to foot traffic. The day is quieter than the previous recording with reduced water traffic allowing those walking and

cycling past to be heard in greater detail: footsteps, clothing rustling, the stomping and puffing of joggers, bicycles, and passing conversations are all heard. In the recording the whine of a leaf blower is heard approximately two hundred metres away and has more presence in the quietude of a usually loud location, “the sound of neighboring televisions and leaf blowers can seem even more intrusive in quarantine” (Bui & Badger 2020). Birdcall is heard clearly while the drones emanating from the Opera House again provide a bed of anthrophony, the sound of traffic and passing trains over the Harbour Bridge now gently resonating through the harbour. With both these recordings it is possible to hear in detail the revealed sonic substructure of Sydney Harbour comprised of; building drones of Circular Quay, occasional traffic from the Sydney Harbour Bridge, ferries, and water lapping against the harbour side.

Figure 61: Sanken COS11 microphones set on the handlebars.

Figure 62: deserted Opera House promenade.

Figure 63: promenade and Opera Bar.

Figure 64: an empty Opera House forecourt

2.1.3_Circular Quay, wharfs 4 & 5 (59dB SPL A)

Circular Quay between Wharfs 4 and 5 was recorded on Easter Monday morning. There are minimal passers-by and sounds are magnified in what is usually a transport hub. Minimal walkers, joggers, and cyclists pass by, seagulls squawk, transport announcements and warnings of social distancing dominate at times, ferry horns sound at what seems like an increased volume, while a drone comprised of the sound of buildings and ferries provides a thick bed of anthrophony. The fundamental sounds of Circular Quay operating are still present and appear louder with the people gone.

Figure 65: outside Circular Quay station is devoid of commuters, buskers and tourists

Figure 66: Entrance to wharf 4

Figure 67: entrance to wharf 5

2.1.4_The Rocks_ MCA (55dB SPL A)

2.1.5_The Rocks_Sargent Majors Row (52dB SPL A)

The quietude of The Rocks is heard in two recordings on Easter Monday. Opposite the Museum of Contemporary Art there is the occasional walker, passing car or cyclist, briefly a television news crew documents a café open for takeaway only. To the right at Circular Quay station the low frequency rumble of trains passing above are heard loud and in solitary detail with a comparison between the sonic characteristics of trains and trams presented in the quieter soundscape. Sergeant Majors Row on George St is similar with a small number of joggers and cyclists, a mother and father passing with a crying child and the occasional plane are the primary intrusions. This location is further from Circular Quay station and marginally quieter, but nearer to the Harbour Bridge

where heavier vehicles and trains are sometimes heard echoing down the hill as they travel over the bridge. The Rocks area, an iconic site and tourist stop, is heard in quietude with both recordings demonstrating the extent of the lockdown on tourism.

Figure 68: George St The Rocks opposite the Museum of Contemporary Art.

Figure 69: opposite the MCA looking left

Figure 70: opposite the MCA looking right to Circular Quay station

Figure 71: Sargent Majors Row at The Rocks

Figure 72: Sargent Majors Row looking towards George St

Figure 73: Sargent Majors Row looking towards the Harbour Bridge

2.1.6_Martin Place (65dB SPL A)

2.1.7_Martin Place Elizabeth St (63dB SPL A)

2.1.8_ Martin Place George St (60dB SPL A)

Martin Place is captured over three recordings; foot traffic is minimal, single trams and busses passing by are captured individually and clearly, while the drone from buildings dominates the soundscape as a thick fundamental and independently illuminate the acoustic properties of the reverberant thoroughfare. In the centre of Martin Place the drones of nearby buildings and a

construction site dominate the recording, the distant Martin Place fountain is heard in the right of the stereo image, while the occasional birdcall sits within these. Early in the recording an intoxicated, friendly fellow enters the recording singing, then startled at the microphones initiates a short conversation followed by a short song about 'Corona', his voice is then lost in the level of the drones as he walks away. The Martin Place bells ringing out in isolation at 6pm is supported by the squawk of crows that adds to the desolation, creating a comically ominous and often-used sound design cliché. Pedestrian crossing signals are heard with the occasional passing bus or motorcycle. However, the main point of interest is the dominance of the now prominent building drone in the absence of the usual layers of human presence. Two following recordings at Martin Place were recorded on the 5th of April 2020. The first at the Elizabeth Street intersection captures the sound of pedestrian crossings, passing buses, the geophony of wind blowing through autumnal trees, and at times the sound of construction around the corner. The second recording made at 5PM is at the quieter end of Martin Place next to George Street; passing trams are heard clearly in the quietude, and, while the now-familiar building drones and distant fountain provide the underlying din, there are instances when the recording contains this din alone.

Importantly, Martin Place is where building drone is first clearly recognised as a detail fully revealed through lockdown. It is present throughout many of the locations and is a theme to emerge throughout the recording process. It is similar to the "baseline" (Bui & Badger 2020) and is the fundamental sonic substructure of the city. Like room tone - the fundamental resonance of an empty room caused by the inevitable surrounding urban anthrophony and even subtle geophony of wind entering - building drone is heard to be the fundamental sonic substructure that resonates through the city.

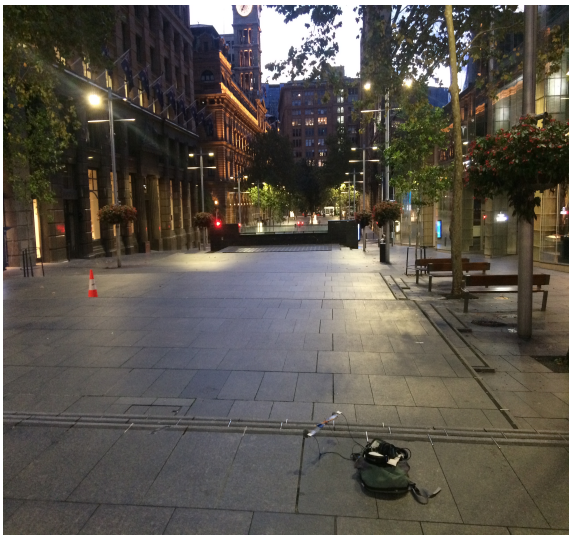

Figure 74: Martin Place with a thick fundamental of building and construction site drones

Figure 75: Martin Place on Elizabeth Street

Figure 76: Martin Place looking at George Street

2.1.9_NSW Parliament House (53dB SPL A)

2.1.10_Hyde Park Barracks (55dB SPL A)

Recordings on Macquarie Street opposite NSW Parliament House and outside Hyde Park Barracks present a usually busy street reduced to minimal traffic. Opposite NSW Parliament cars are minimal and a few empty buses drive along the usually busy roads; the sound of bicycles ticking past is now a theme throughout the recordings that reflects a reported rise in the popularity of cycling during lockdown (Mark 2020). The quietude is accentuated in the recording by extreme limiting caused by a passing motorcycle; the unexpected loud volume of the motorcycle is in stark contrast to the newfound city quietude and recording levels were not set accordingly. Once the sound of the motorcycle dissipates, we are left with a brief moment where the building drone and subtle din of distant traffic are the only sounds present, only the most fundamental layers remain.

Figure 77: New South Wales Parliament House

Figure 78: opposite State Parliament looking towards Circular Quay

Figure 79: State Parliament looking towards Hyde Park

Hyde Park Barracks is similar in detail but with a stronger fundamental layer of mechanical building drone and distant traffic; the open street corner allows these factors to combine and provides a vantage point for them to be heard.

Figure 80: Hyde Park Barracks

Figure 81: corner of Hyde Park Barracks

2.1.11_Pitt St Mall (56dB SPL A)

Pitt St Mall, recorded in the early evening on Sunday the 29th March 2020, is reduced to an empty thoroughfare with crowds, buskers, and muzak replaced by the drone of buildings in shutdown. In this large shopping centre building drone is central, the sound of traffic coming from the end of the mall on Market St is also present, and the beeps of pedestrian crossings (another sound heard throughout the collection) sit within the din, few passers-by are present and low-level music barely emits from a downstairs supermarket. Of most interest are areas where building drone is the sole sound perceived in the recording.

Figure 82: an empty Pitt St Mall

2.1.12_Dymocks Building (60dB SPL A)

George St in front of the Dymocks building is again dominated by building drone punctuated by passing empty trams recorded singularly and clearly with both foot and road traffic greatly diminished. Instead of commuters or shoppers we hear a smattering of people walking the city. The warning beeps of a garage opening pierce the recording, again indicating the amplitude needed to overcome the usual pre Covid-19 volume of the soundscape.

Figures 83: the Dymocks Building on George St looking left to the Queen Victoria building

Figure 84: the Dymocks building looking right to Circular Quay

2.1.13_Town Hall (57dB SPL A)

Further along George St the front of Town Hall is recorded. The Town Hall bells chime clearly at half past the hour and dominate, with the squawks of seagulls also prominent.

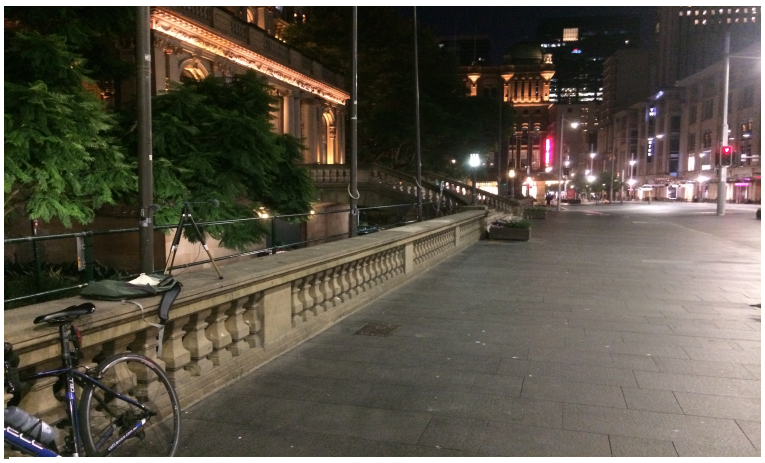

Figure 85: in front of the Town Hall on George Street

2.1.14_QVB tram stop (59dB SPL A)

The QVB tram stop between the Dymocks building and Town Hall was recorded at 11AM on Monday the 13th of April 2020 and holds similar characteristics to the early evening recordings at the Dymocks building. The acoustics and building drone are different here which alters the sonic substructure. However, of interest is that this morning recording holds similar characteristics in content and volume to the previous nearby evening recording, indicating that according to these sound recordings, the daytime soundscape was similar to the night. Certainly being on location and the subjective act of listening this to be the case.

Figure 86: Queen Victoria Tram stop George St

Figure 2 Figure 87: Easter Monday morning on George St at the QVB tram stop

2.1.15_China Town (54dB SPL A)

China Town was recorded on the 4th of April 2020 and is comparatively silenced for a usually busy restaurant strip on Saturday afternoon. Mechanical building drones and wind blowing leaves dominate and are heard loud and in detail. Passing foot traffic and conversation is slight, immediate and distant road traffic minimal, building repairs are being carried out. Halfway through the recording a distant Chinese pop song echoes down the street, while the occasional food delivery bicycle replaces the bustle of restaurants, representing the hospitality industry in shut down and a new dependence on casual bicycle delivery.

Figure 88: China Town shutdown on Saturday afternoon

Figure 89: China Town

2.1.16_UTS Student Centre 10th April (33dB SPL A)

2.1.16A_ UTS Student Centre 12th April (36dB SPL A)

Locations in and around the University of Technology Sydney were recorded on the 10th and 12th of April 2020 over the Easter weekend. The first recording sees the bicycle used as a microphone stand and placed against a seat. The Student Centre is usually teeming with activity but, due to lockdown and the Good Friday holiday, it is recorded with largely no human activity present barring a few instances of distant movement and a solitary person entering the cavernous foyer through the automatic door. External sounds of buses rumbling along

Broadway sometimes enter. As the sun comes out from behind the clouds and the building warms, creaks and cracks of the building expanding, that would usually go unheard beneath the primary anthrophony, now dominate. The building affected by the weather is heard as a combination of anthrophony (the sonic presence of the building) and geophony (the sun coming out from behind the clouds), the building may be heard as being played by the sun. A second recording at the Student Services Centre on Easter Sunday contains occasional human movement with a slightly altered fundamental drone, due to the use of a higher tripod stationed in the centre of the thoroughfare. The building creaks are reduced given the constant sun exposure on the day.

Figure 90: UTS Student Centre with microphones on handlebars

Figure 91: Student Centre looking towards Jones St

Figure 92: 2nd recording at the UTS Student Centre with microphones in the centre

2.1.17_UTS The Goods Line (57dB SPL A)

2.1.18_UTS The Alumni Green (52dB SPL A)

2.1.19_ UTS Building 2 (42dB SPL A)

Other recordings around the UTS also demonstrate the shut-down of higher education with the dominance of building drones and diminished traffic from Broadway. A recording of The Goods Line is another example of exterior building drone coming to the forefront. This building drone dominates and engulfs the sound of leaves blown along the ground, occasional foot traffic, and helicopters. The presence and volume of such building drone became a recurring fundamental theme of the city soundscape. The Alumni Green courtyard between UTS buildings seven and ten, whose sound was captured on Easter Sunday, again features building drone, birdcall, and traffic on Broadway with very few passers-by. Building Two containing the library, food court and lunch areas, should be a hub of activity but instead we hear buses travelling along Broadway, the occasional sound of escalators and elevators, and just a few students moving or chatting.

Figure 93: The Goods Line at the UTS

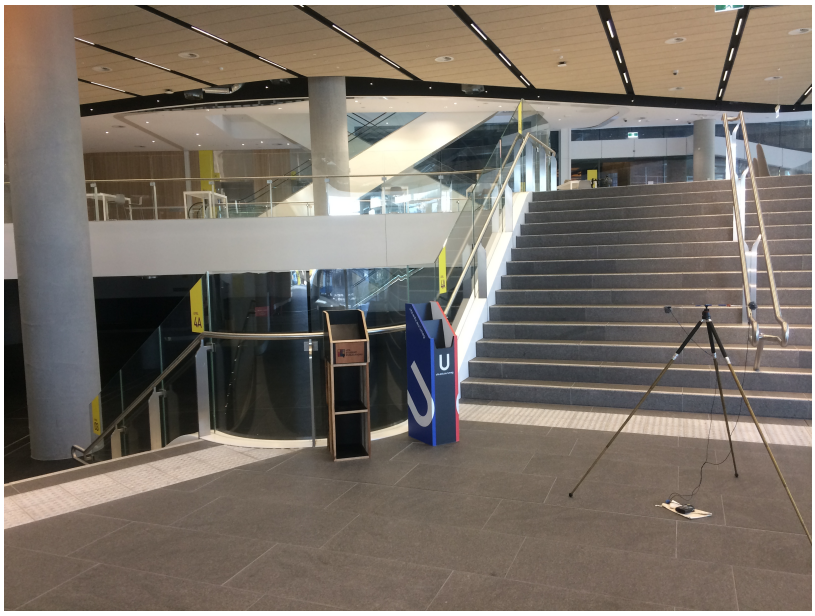

Figure 94: UTS Building 2

Figure 95: UTS, The Green

Figure 96: UTS, The Green

2.1.20A_Central Station Tunnel 4th April (52dB SPL A)

2.1.21_Central Station Tunnel 12th April (53dB SPL A)

Central Station Tunnel is brought down to a level where the low frequency rumble of trains passing above dominates at intervals with the absence of other sound, emphasising its true volume. Buskers and the sound of the daily commute are non-existent, minimal passing footsteps are heard in a detail, and occasional food delivery bicycles are heard as they pass quickly by the stereo image. Similarly to the State Parliament recording, the words of singular passing conversations are sometimes discernable, providing a brief insight into passing lives as opposed to the usual indiscernible cacophony. Given reduced anthrophony, details are also heard coming from each end of the tunnel with

intermittent distant pedestrian crossings and birds present. The tunnel itself is heard with a diminished acoustic illumination as opposed to the overpowering accumulation of sounds that would usually reverberate through the tunnel.

Figure 97: Central station pedestrian tunnel looking towards Broadway

Figure 98: Central station tunnel looking to Chalmers St

2.1.21_Railway Square (66dB SPL A)

At Railway Square buses are still present but with the lack of road traffic these now contend with the squawks of the seagulls. The usually continuous flow of traffic through this main road is dramatically reduced with buses the prime source of traffic noise.

Figure 99: Railway Square

2.1.22_Chalmers St tram stop (60dB SPL A)

The Chalmers Street tram stop recorded on Easter Sunday captures passers-by walking and jogging, Central station announcements and trains, with trams arriving and leaving. Similarly to Railway Square, while the recording does at times sound relatively busy it must be remembered it is a central public transport hub where commuters, trains, trams, busses and other traffic would usually culminate to form a city corner roar.

Figure 100: Chalmers St light rail stop looking to Central station

Figure 101: Chalmers St light rail

2.1.23_Hyde Park (53dB SPL A)

Hyde Park was recorded on Easter Monday at midday. People are briefly out of isolation in the sun but not in the usual number; the details of footsteps and clothing rustle are again heard. Of note is once again the building drone. Hyde Park is a considerable distance from buildings and roads so the sonic perspective is one of distance that creates a accumulation of these base level sounds, as opposed to being next to and within these sounds we can hear them from a far as they begin to combine. A city park provides refuge from the immediacy of concrete surroundings, here it is heard as a sonic island cut off from immediate sound sources while the din of building drones and traffic surrounds it.

Figure 102: Hyde Park

2.1.24_Enmore Park next to Llewellyn St (49dB SPL A)

A recording taken at Enmore Park presents a general park soundscape with the sounds of children playing, people exercising and dogs barking. Notably, the recording is uninterrupted by the usual barrage of low-flying aircraft. Additionally, there is less traffic coming from the usually busy Enmore Rd in the right of the stereo image with most traffic sound coming from the quieter Llewellyn St behind. Significantly, at this final location, which is far from large city buildings, the consistent fundamental building drones heard throughout the collection are now suddenly absent.

Figure 103: at Enmore Park

2. Bourke to White Cliffs Sound Recordings.

See submitted sound library:

3.1 Bourke to White Cliffs Sound Recording.

In these recordings only minimal noise reduction has been used to leave the recordings relatively untouched but reduce excessive noise floor. Importantly it must be remembered these are very quiet locations and the recording level is very low and system noise high. Following my SPL meter that had a lowest limit of 30dB SPL C, all locations were below 35dB C weighted but generally stayed within 30dB -32dB SPL, none went below 30dB but it is thought many locations were lower. All recordings have already been increased by +12dB. It is recommended to listen to the recordings through headphones, in a quiet environment, at a low-level.

3.1.1_location 1.

The submitted sound recordings begin at Toorale road selected simply because it was off the main Bourke-Milparinka road. In this five-minute excerpt, microphones were set amongst small trees where it was surprisingly quiet. During the recording chirping bird life is present within the vegetation, a car drives along the Toorale road and the driver asks if I'm 'right' as they pass approximately 20 metres way, while at one point distant machinery or cars are just audible, and the wind is minimal. Here vegetation dampens the sound of surrounding winds and the distant anthrophony from a cotton field.

Figure 104: Toorale road near location 1.

Figures 105: location 1, 20 metres off Toorale road in the scrub.

3.1.2_location 2.

Over the trees nest to the Bourke-Milparinka road a small saltpan is recorded. Out of the trees the location is slightly louder with more surrounding birdcall, wind, and traffic on the main road approximately one hundred metres away. Yet, between the cars this location is also surprisingly quiet.

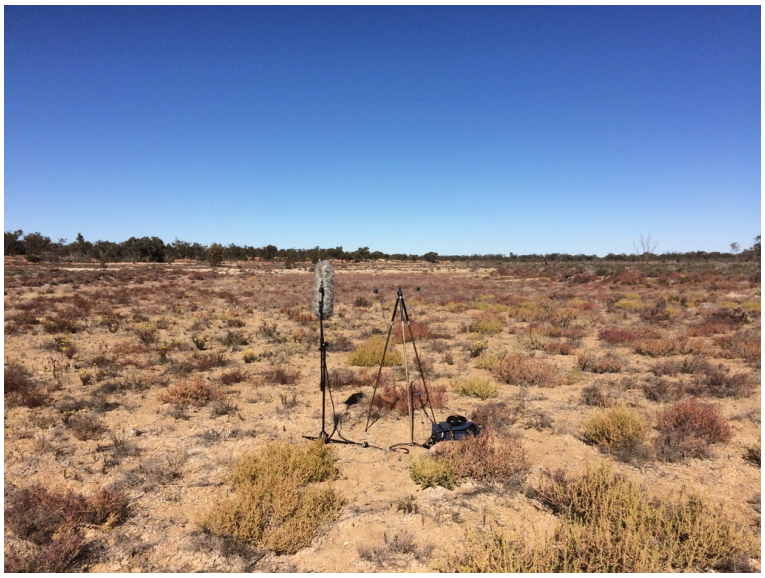

Figure 106: location 2, saltpan next to the Bourke – Milparinka road

3.1.3_location 3.

Along Snakes Gully Rd to Fords Bridge, is a plain with larger eucalypt trees to the east. This area appeared to be recently untouched with no current evidence of human or animal tracks in the soft sand. There are stronger wind gusts, birdcall, flies buzzing, and distant bleating from a herd of goats under the eucalypt trees. Given goats are an introduced species this could also be seen as a form of anthrophony introduced to the soundscape.

Figure 107: Location 3, Snakes Gully road recording location

Figures 108: location 3, Snakes Gully road

3.1.4_location 4.

The following morning at Heffernans Lane near the northern entrance of Nocoleche Nature Reserve there is distant traffic and mid morning birdcall in the taller trees and nearer the Paroo river.

Figure 109: Location 4, recording next to Heffernans Lane

3.1.5_location 5.

Further south a dry dam is used in an attempt to shelter under the wind and surrounding sound. Here again we are left with surrounding birdcall similar to the last two recordings but there are now brief moments of no birdcall or wind. The soundscape is becoming quieter here.

Figure 110: location 5, recording in a dry dam.

3.1.6_location 6.

20km south along the Bourke-Milparinka road a barren area of minimal immediate vegetation was selected. Even though distant and quiet, birdcall is surprisingly present with birds in the surrounding but minimal tree coverage. The slight gusts of wind against the microphones are exaggerated in the low-level recording with volume increases in postproduction to hear the very quiet soundscape further emphasising these.

Figure 111: Location 6

Figure 112: location 6 looking towards the main road

3.1.7_location 7.

A further 24km south we come to the quietest daytime recording within this research and what is surely one of the quietest places on Earth. This recording captures an example of the natural, ancient, near-silent sonic substructure of the natural environment. Here there is occasional distant birdcall, and areas of only the gentle winds blowing across the landscape between stronger gusts that are heard against the microphones. On location my ears strain to hear anything throughout the 30min recording process, the soundscape is crisp. When talking towards the microphones to give location details words seemingly dropped to

the ground as they do in an anechoic chamber with no surfaces other than the soft dirt ground to reflect frequencies. When speaking at approximately five metres behind the car, the area is quiet enough to hear my voice bouncing of the car; the presence of the car itself is heard as a sonic obstacle interrupting the base level geophony.

Figure 113: location 7, the quietest daytime location, microphones are can be seen in the distance.

Figure 114: location 7, main road at the quietest daytime location.

3.1.8a_location 8a.

3.1.8b_location 8b.

14km along the road a final recording is captured at night and is the quietest recording on the ground in this research. There two recordings captured, one at 7:20pm (3.1.8a_location 8a) and the second recording beginning at 8:30pm running into the night for 3 hours 20mins (3.1.8b_location 8b). Sleeping outside on the ground in the silence without the act of recording, allowed time to listen in detail. The biophony was almost non-existent except the few occasional bird and insect calls (at 3:30 in recording 3.1.8a_location 8a), and in the still of night with very little wind in the immediate vicinity it is quieter than the day. The ear strains to hear any environmental sound at all and mostly none is detected. It is a natural and extreme quietude. In the recording, occasional sparks from the low campfire are heard from approximately 30m away, also providing a useful reference for noise reduction. The short sharp clicks work as a location reference sound in the quiet of the desert, the sonic definition of the higher frequencies indicate how much noise reduction is being applied and whether this is affecting the recording of the sonic environment and removing any of the soundscape. In excerpt 3.1.8b location 8b at 15 seconds and again at 1:11 very gentle, low-level winds can be heard seemingly blowing across the landscape.

However, as previously stated there is still a sound present other than simply that of my hearing system. On location and in recording there are no clear sound sources in the immediate vicinity so it is thought this is made up of surrounding gentle winds resonating over the landscape. There are instances of slight winds heard in the recording as a gentle howling.

Figure 115: location 10, night recording location with microphones in the distance

Suitably, these final two night recordings in the progression capture the quietest environments and mark the final exterior recordings on the ground within this research. The sound layers are peeled back through remoteness, become increasingly delicate, and reach the lowest level possible with a final night recording. These are examples of the quietest possible natural environments that contain an ancient and exceptionally rare sound free of animal life with only the vegetation contributing to the sound of very subtle winds. This is the lowest sonic substructure thought to be, at least in part, comprised of gentle surrounding winds that combine to create a subtle din. The locations and resulting recordings hold characteristics similar to an anechoic chamber yet there is still sound present.

3. Weather Balloon Flight 3 Altitude Data.

Date	Time	GPS Altitude (metres)
14/2/20	10:43:47	541
14/2/20	10:44:27	756
14/2/20	10:45:07	959
14/2/20	10:45:47	1160
14/2/20	10:46:28	1360
14/2/20	10:47:07	1559
14/2/20	10:47:47	1762
14/2/20	10:48:27	1960
14/2/20	10:49:07	2157
14/2/20	10:49:47	2350
14/2/20	10:50:27	2563
14/2/20	10:51:07	2778
14/2/20	10:51:47	2973
14/2/20	10:52:27	3174
14/2/20	10:53:07	3363
14/2/20	10:53:49	3552
14/2/20	10:54:27	3751
14/2/20	10:55:07	3958
14/2/20	10:55:47	4130
14/2/20	10:56:27	4329
14/2/20	10:57:07	4530
14/2/20	10:57:47	4730
14/2/20	10:58:27	4943
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14/2/20	11:01:47	5899
14/2/20	11:02:27	6084
14/2/20	11:03:07	6312
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14/2/20	0:16:27	9643
14/2/20	0:17:07	9795
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14/2/20	0:21:07	10534
14/2/20	0:21:47	10654
14/2/20	0:22:27	10784
14/2/20	0:23:07	10954
14/2/20	0:23:47	11081
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14/2/20	0:31:47	12589
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14/2/20	0:33:49	13038
14/2/20	0:34:27	13218
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14/2/20	2:01:07	5097
14/2/20	2:01:47	4666
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14/2/20	2:05:47	2491
14/2/20	2:07:47	1477