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Sound Opportunity:

A Proposal for the Future of Audio Engineering and Production at WPI

A Major Qualifying Project Report:

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of the

WORCESTER POLYTECHNIC INSTITUTE

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Degree of Bachelor of Science

by

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This report represents the work of one or more WPI undergraduate students submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review.

## **Abstract**

This project is the culmination of research and practice in the field of audio engineering. The aim is to propose a design for a new recording studio and audio engineering environment at WPI. This goal is achieved by researching numerous recording studios and performance venues in London during E Term, 2009 to decide on the best equipment and space for this environment. It is also achieved by completing professional audio production projects in the realms of multi-tracking and live ensemble, and establishing procedure for these kinds of projects in the future of WPI.

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## **Introduction**

To understand where this project is seeded, I feel it is best for me to explain a bit of my history and how I reached the point of participating in this project. When I first came to WPI as a freshman, I came in with a heavy interest in electronics and music. I declared myself as an electrical and computer engineering major, with plans to study audio applications, and engrossed myself in all the music division had to offer for courses and ensembles. I did not hesitate in getting involved with the Men's Glee Club, as well as gaining acceptance into smaller audition groups like Vocal Performance Lab (chamber) and Simple Harmonic Motion, the men's a cappella group. I also became heavily involved in VOX, participating in musical theater. I found myself taking several music classes and developing great working relationships with much of the Music Division.

While taking electrical engineering classes in my sophomore year, I found I desired more of a concentration in music and audio applications. First, I looked to the Electrical and Computer Engineering Department for audio applications of electronics. I used my knowledge of electricity fundamentals in projects, including in Electrical and Computer Engineering Design, where my team designed a noise dosimeter for monitoring hazardous sound exposure. I also searched for an audio recording studio environment. I was quite shocked to find that a technical university did not have a true recording studio. I helped to organize the fledgling WPI recording studio that exists in the basement of Alden Hall.

Today, the main established group that performs audio capture and production on campus is the Recording Club. The club offers services of audio

recording and production to the campus and serves as an opportunity for interested students to learn these skills. The club began with a few enthusiastic students and equipment donated from the Humanities and Arts Department, WPI alumni, and other outside parties. A similar organization was started before I was a student at WPI but faded. It was revived in my freshman year with another small interest group of students, including myself, Alex Dismore (2008), Jeff Madden(2008), and Peter Worrest (2011). The four of us took what we optimistically called a studio and started systems for cataloguing, scheduling, and organization.

After this interest group organized, I knew the next steps would include achieving *official Class I* club status to take advantage of all of the benefits club status at WPI has to offer: advertising on campus, the ability to SFR for items (including equipment upgrades, etc.), and establishing a budget.

During my Junior year, the process of organizing the club caused me to examine my own college career and made me question if I should be pursuing my audio interest solely on an extra-curricular basis. I concluded that I wanted to prepare myself to work in a studio, and felt that the best option for me was to look to an arts school with a reputable program. While contemplating transferring, I realized how much I really liked the environment at WPI: the meaning that *Lehr und Kunst* has for me, the connection with faculty I had worked with, how many opportunities are offered to students who wish to specialize, innovate, and work independently in our ever changing tech-centric world.

I realized that WPI gives opportunities to students seeking independent majors, and decided that an Individually-Designed (ID) major was my best option. I

pursued an ID major in Audio Engineering and Production. By designing my own curriculum, I was able to create the right program for me. Through my curriculum, my goal was to use the knowledge I acquired and extend it to assist the recording club, establish a recording studio and an audio engineering environment for future WPI students with interests in audio. I knew in doing this I would prepare myself for a successful career.

I was active president of the recording club for two years. During that time, we achieved Class VI provisional club status. I mentored and trained younger students in the studio, publicized the club, and prepared the members for future recording and production project opportunities.

Working extensively with the Humanities and Arts Department, Music Division, music ensembles on campus, and the growing number of students interested in audio, I have developed a working system for audio projects at WPI. In addition, through exposure to the industry, and other academic sources, I can establish that which is the very intent of this Major Qualifying Project, a proposal for the future of the audio engineering and production environment at WPI.

## **WPI Audio Facility Needs and Considerations**

In proposing plans for a future studio at WPI, there are specific aspects we must consider. What instruments are being recorded? Where are the recordings being captured? What equipment is used to capture the recordings including microphones, microphone preamps, audio hardware interfaces, mixing boards, as well as software to record with (Digital Audio Workstation, or DAW), effects and signal processing units (outboard gear and software)?

The question of what instruments are being recorded is significant when planning for a space and equipment. For instance, a large choir is best miked with a pair of small diaphragm cardioid condensers, and/or a pair of omnidirectional condensers while a live jazz band would call for more close-miking, and a rock band would be recorded multi-track with close miking on everything.

The Recording Club currently does projects across the spectrum including live recordings of all the main ensembles on campus, including Concert Band, Orchestra, Jazz Ensemble, Stage Band, Glee Club, Alden Voices, as well as multi-track projects for the campus a cappella groups and smaller student bands. The expanding variety of projects and ever changing needs of the musicians at WPI really call for a significant expansion of resources in the form of live space(s), and equipment for higher quality performances and recordings.

## **Problems with Current Facilities & Equipment**

When considering the ideal spaces to record in, we need to keep in mind live recordings in addition to multi-track recordings. There are currently no desirable rooms for control/listening, or production of audio. There are also no desirable places to capture audio, live or multi-track, on the WPI campus.

### ***Recording Studio Control/Listening Room***

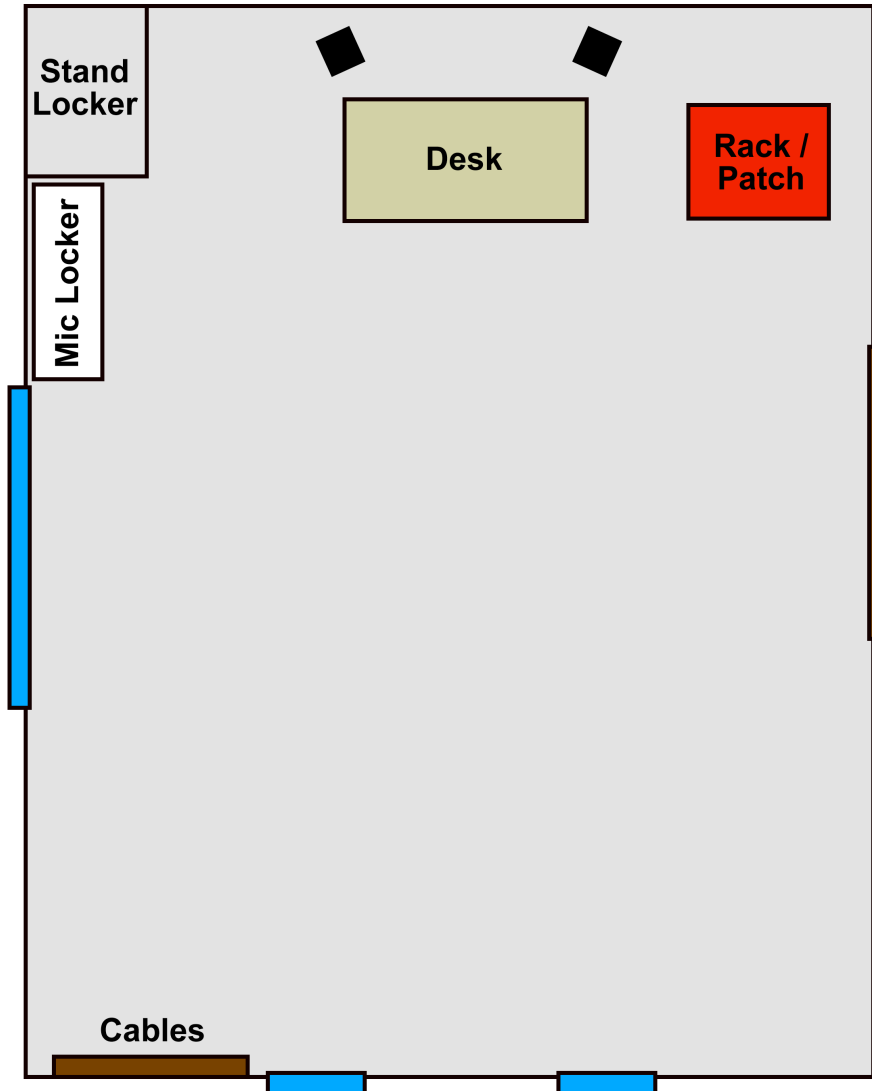
There are numerous acoustical issues with the current Recording Studio in the basement of Alden Memorial. It acts as the control room/listening room for audio capture, as well as the production studio. While it is fairly common to see an environment where all of these things are done in the same room, it is not an adequate space for all of these purposes.

The main problems lie in the fact that this room was not actually designed as a studio. The room was designed as a practice room, and became a storage closet for the music division. The principle issues include: the room has all parallel surfaces, and it is built on two outside walls (both of which have tall windows on them letting in copious amounts of external noise from the street and campus). It is located in the corner of the building directly next to (and without any acoustical separation from) Spaulding Recital Hall, which is used daily for rehearsals of campus ensembles and student groups. There are multiple hours in the day where anyone who has experience recording would not think about using this room because there is horrible bleed from Spaulding in addition to the noise from outside and from the heating and air conditioning vents. Again, the main issues with the



space lie in the fact that it was designed to an equipment room/small rehearsal space, and definitely not a control room or recording studio.

A map diagram of the room is below:



**Figure 1: Alden Memorial Recording Studio Control/Listening Space**

### ***Small Ensemble Live Space***

Many of the recordings of small campus ensembles are captured in the Spaulding Recital Hall. The room is constructed mostly of wood, which is a desirable material for a live space. Unfortunately, it is built on an outside wall causing a fair amount of external noise problems. In addition, there are multiple parallel surfaces in the room, which create an undesirable acoustic effect known as *comb filtering* (further explained in the Practical Solutions at WPI section). There are also two large beams in the middle of the room that run floor to ceiling. It is satisfactory room for small ensemble/recital performances, but not a good space to capture recordings.

### ***Large Ensemble Live Space***

Many of the recordings of large campus ensembles are captured in Alden Memorial's Great Hall. The space is beautiful and has great history but for the purposes of live performance and recording the room does not have very good acoustics. For a hall of its size, sound seems to get lost and musicians generally cannot hear themselves playing very well in the room. Also, two of the walls of the hall are outside walls allowing a lot of external noise to come into the room. This is quite undesirable for especially recording purposes. In addition to significant amounts of external noise, there was also a large air conditioning unit installed in the hall recently, which makes temperatures more bearable in the warmer months, but causes a significant amount of noise in the hall. (Problems of internal and external noise are discussed more in the Practical Solutions at WPI section.)

### ***Multi-track Recording Spaces***

In addition to the problems with live spaces for ensemble recording, there are significant problems with doing multi-track recording projects at WPI. In order to do multi-track recording well, you must either have a purpose-built isolation booth or a small room with a very “dead,” acoustic, and absorptive baffles to keep reverberation to a minimum in the room. (Discussion about the process of multi-track recording is further explained in the *Relative Industry Experience* section and I also discuss ideal isolation booths in the *Practical Solutions at WPI* section.)

### ***Equipment & Software***

While the quality and quantity of equipment has vastly improved since I started working in the studio, there are still some equipment issues that need to be addressed. One of the big equipment questions is the industry popular debate of analog v. digital equipment question. I have discussed this topic with numerous people, including engineers in London during summer 2009.

Joe Leach at Cowshed Studios in London feels that some digital equipment works well. He highly recommended using different software as well, including Digital Performer, used on many feature films. However, he feels that overall digital equipment requires constant expensive upgrades to work. His recommendations include a small analog desk because it will always work and never needs an upgrade. Leach says of Digidesign, creators of industry standard digital audio consoles and hardware as well as the industry standard software Pro Tools, “I hate Digidesign...I think they’re wankers.” (Leach, 2009) While Leach is not the only one I spoke with to dislike Digidesign, or more concisely, digital equipment, I did receive

a barrage of positive comments and feedback regarding digital equipment from engineers, studio owners and staff.

Ian Stonehouse at Goldsmiths University, London is one of the many supporters of digital equipment. He told me that the positive trait of digital was reliability and quality, while the major negative was price. I found this to be interesting, because, while Stonehouse called digital equipment reliable, Leach gave the impression that it was the exact opposite. I believe that the main difference in the equipment, besides continuous analog capture versus discrete-time digital capture is the need for upgrades on the digital consoles. From my personal experience, and many engineers I spoke with, if you keep the software as updated as possible, you will be extraordinarily happy with the results of digital equipment.

The major equipment or “big ticket” items that are needed include: at least one main control surface/mixing console and interface. The studio currently has Digidesign 003 console running Pro Tools 7. This is a digital console with eight channels but only 4 microphone preamps. There is an additional small Mackie mixer in the studio with additional preamps but at most, you can record only eight microphones simultaneously. This is adequate amount in some cases but many instances we come across at WPI including miking drums with ensembles, or miking individual voices for an a cappella show call for more channels. The recording club recently passed an SFR through SGA for equipment and an operating budget. They are obtaining a Mac Pro. Which is a more capable and highly upgradeable desktop computer. They are also obtaining storage space for audio.

One issue that the recording club faces on a regular basis is to capture audio in locations outside of Alden Hall. Much of the club's equipment is not easily transportable. One example of a live recording that the club is currently unable to capture or produce effectively is an a cappella show miked with wireless Shure ULX headset microphones. The problem is that none of the club's equipment is very mobile, and what is mobile does not have enough channels to record all of the mics for the show.

Where the studio equipment severely lacks is microphones and production software/equipment. As I stated previously, the diverse kinds of recording projects undertaken at WPI really call for high quality equipment capable of capturing and producing diverse products. No matter what type of music you are capturing, you are going to need microphones.

As of right now, the recording club really owns two microphones: a pair of Brüel & Kjær 4006 omnidirectional condenser microphones. These microphones are outstanding for recording classical performance and various ambient sound recording scenarios but the pair is not enough. The other mics used in the studio include a small number of dynamic mics including Shure SM57s (decent for miking instrument cabinets) SM58s (generally a live performance vocal microphone, not advisable for recording vocals), and a Beta 52A kick drum microphone. (I am under the impression these mics all belong to the Jazz Group and not the Recording Studio.) In addition, there is an AKG 3000B cardoid large diaphragm condenser microphone suitable for recording and performance as an area/sectional

microphone, providing high gain before feedback. (I believe this microphone belongs to Professor Bianchi/the Music Division.) In addition, Vox owns Shure ULX wireless headset mics, and has recorded vocal ensembles like the a cappella groups with them in the past, however the recording club does not own any of these additional microphones, and they can become unavailable for recording projects without the consent of the club. Many additional microphones are needed to successfully capture and produce the kinds of projects that happen at WPI on a regular basis.

Production tools and equipment, whether they be in the form of software (current standard) or outboard equipment (old standard with analog equipment) are needed to produce quality work. These include: digital signal processing (DSP), equalization (EQ), reverbs, effects, pitch correction/shift tools, virtual instruments/samples. (Further discussion, and all of my proposals for spaces and equipment can be found in the *Practical Solutions at WPI* section.)

## **Observed Spaces & Industry/Academia Interviews**

In partial fulfillment of my Major Qualifying Project, I studied in London for E Term, 2009. I visited various recording studios, audio production facilities, and performance venues, both academic and professional, to see what industry and academia facilities are doing. I interviewed several accomplished industry professionals to discuss their experiences in the field, industry standards for equipment, room design/treatment, as well as equipment and space preferences for different kinds of work. I interviewed a staff member at nearly every studio space I visited. A list of my interview questions can be found in Appendices A and B. In addition, I have attached my acoustical and musical observations from some churches and performance venues in the city. These can be found in Appendix C. Many of the answers I received contained valuable advice and information. The following are examples of facilities I visited while in London and the United Kingdom:

On a day trip to Manchester, I met with David Berezan, PhD, Director of Electroacoustic Music Studios at Manchester University. Doctor Berezan had the opportunity of being part of the team that designed their £2.2 million purpose-built electroacoustic music studio facilities, built in 2007. The facilities were thoroughly well designed. Their equipment was top notch digital equipment, and the structure included studios with a “box within a box” design. This concept is explained in the solutions section. The construction was done with chilled beams in order to avoid noisy air conditioning units. They also had a “machines room” for noisy machines and electronic devices. Technically, these facilities are electroacoustic music

studios, but, from a structural design standpoint, these facilities are a perfect model for a control/listening room. Dr. Berezan was generous enough to send me blueprints of the NOVARS facilities. These could be a great reference for designing new facilities at WPI. These blueprints can be found in Appendix D. Some photos I took of the facilities can be found below:



**Photo 1: The NOVARS Audio Composition and Research Facility**



**Photos 2-3: Studio and Machines Room at NOVARS**



After correspondence with their Centre for Digital Music graduate research team, I visited Queen Mary University, London. I spoke with a few graduate students: Becky, conducting research in binaural audio, and Enrique, who was working on automatic mixing technology. To explain a bit more, he told me, “Basically, I want to take away my own job.” (Gonzalez, 2009) The students showed me some of the main facilities they had, Mainly consisting of a small room, designed as a listening room. There was a machines room underneath the listening room to reduce noise, with a trap door to access the servers and computers running below. After short observation, the room seemed to have a desirable acoustic for a listening room. However, Becky and Enrique told me the University received grant money for the space and built it, without actually knowing the precise field of research that would be conducted. It was designed with no parallel surfaces, with a machines room, and as a room within a room, and no outside walls, to provide desirable listening acoustic and minimal outside noise. Some of issues and problems include heating, ventilation, and air conditioning (HVAC), and, although the room has a good acoustic for a listening room, it was designed without any patch bay to outside rooms therefore the signal cannot leave the room unless the air seal is broken on the door. Below are a few of my photos of Queen Mary’s facilities:



**Photos 4-5: Queen Mary University, London's Listening Room**

I met with Ian Stonehouse, Head of the Electronic Music Studios at Goldsmiths University, London. He discussed the programs they have at Goldsmiths, including undergraduate studies in Music and Popular Music as well as graduate studies in Composition, which can include a concentration in acoustic composition or studio composition. Goldsmiths also has doctoral programs in soundscapes and electronics. Their facilities were designed as recording facilities. In speaking of recording interfaces, Stonehouse said it really depends on budget, citing examples of Goldsmiths using Pro Tools, with three HD2 systems, as well as software including Cycling 74, Ableton Live, and Reason. Stonehouse really stressed that Pro Tools is the reliable industry standard for a reason, and the higher price yields desirable results.

I went to Alchemea College of Audio Engineering to see their facilities and equipment. Alchemea is a training facility, focusing on multi-track recording in a close-mic style. Their facilities include six studios, with a Euphonix CS3000 analog console, a Soundcraft 1624 digital console, a Soundcraft DC2000 digital console, a

Digidesign ICON digital console with 5.1 monitoring, an SSL G-Series digital console, and a Pro Tools HD interface with a Digidesign D-Command control surface. Their spaces are great for multi-track recording with small live rooms and isolation booths. An equipment list from Alchemea can be found in Appendix E.

The School of Sound Recording in Manchester was a similar setup to Alchemea, only larger, with facilities including fourteen recording and post-production studios used to teach students about recording and production of multi-track projects. They have several high quality systems, analog and digital.

Because of WPI's involvement with the Sir Arthur Sullivan Society, I was granted the opportunity to sit in on a recording session of *Ivanhoe* at the BBC Welsh National Orchestra's purpose-built facility in the Millenium Centre in Cardiff, Wales. I met with conductor Robin Gordon-Powell, and other contacts from the Sullivan Society. Gordon-Powell called the recording facilities at the Millenium Centre "the most state of the art recording space certainly in Wales, but perhaps the country...certainly the most modern." (Gordon-Powell, 2009) In the live room, there was a high ceiling with acoustic paneling with integrated lighting. There were acoustic panels in the front of the room. All of the surfaces were wood, with treatments on top including side walls with diffusors. In addition, none of the surfaces were parallel. The staffing for the recording was a very common setup including two engineers, one controlling the mixer and equalization, one controlling the recording interface and the take numbers, and a producer who was the only one to communicate with the conductor via a talkback system. Some photos of the

recording space including orchestra and microphone configuration can be found below:



**Photos 6-9: Millenium Centre Recording Space, Layout for Ivanhoe Recording**

At the London International Music Show, I was able to sit in on a Q & A session with the Editor-in-Chief and Technical Director of Sound on Sound Magazine, Paul White and Hugh Robjohns. They were answering questions regarding recording studios and equipment. There were a fair amount of key points to take away from this session. They stressed when doing work in a personal studio, one can take personal preferences with equipment. When operating a professional studio, one should know the industry standards and consider that using industry standards can help to pick up more clientele.

I asked what to do at a university which, performs many different kinds of recording projects (both multi-track and live) and what was the best equipment solution in terms of versatility and mobility. The answer I was given goes back to the fundamentals of capturing audio every engineer learns: Production can make or break a recording but the best product starts with the best capture.

They spoke briefly about equipment, but said that our focus for versatility should be to obtain the proper spaces for recording. For versatility, they recommended rockwall reversible traps to produce sound diffusion or reflection, depending on the application. In regards to mobility, (in order to record in different spaces on campus) they suggested focusing on the functionality and performance of a desktop machine and acquiring an independent unit that records to hard disk so files can be dumped after capture and production can be done on the studio computer. A few units they suggested included the Alesis HD24HR, as well as units by Sadie and Joker.

While in Manchester, I visited Blueprint Studios, and met with Frederik Kindt, a member of the three person team that received training at the School of Sound Recording, Manchester, took a few years to find a space and design all the spaces and treatments for their new studio. The layout was a good layout for recording small rock bands and combos. One design that I found particularly useful was the three-way wall trap. They are essentially reversible wall treatments, except they have three sides, and spin around a center column. One side is the regular reflective wall material, one side is a diffusor, and one side is an absorber.

Depending on the amount of reverberation desired for the live room during recording, you could spin the trap to the appropriate side. A photo of these traps and some of the facilities at Blueprint can be found below, and a full equipment list can be found in Appendix F.



**Photo 10: Three-way Wall traps at Blueprint Studios**



**Photos 11-12: Room Treatments and the view at a desk, Blueprint Studios**

There is also one particular facility I observed in the United States that stands out in my mind, and I feel deserves mention in this proposal: EMPAC at Rensselaer Polytechnic Institute in Troy, New York. I attended this facility to perform with Simple Harmonic Motion, and I was thoroughly impressed with this space. We performed there but I could not help but think what it would be like to record in that sort of space.

The main venue was built as a large wooden room structure with a structural enclosure around it, reducing the impact of external sound. The walls were not parallel. There were fabric ceiling treatments on the tall ceilings as well as diffusers and treatments on the walls. This is a live space that possesses a desirable acoustic for live performance and recording. There are a few photos of EMPAC below:



**Photos 13-14: RPI's MPAC Experimental Media and Performing Arts Center**

## **Relative Personal Industry Experience**

At this stage of my career, much of my industry experience has come from internships and projects I have completed as a student. Two of these projects I would say are pillars examples of projects that are very different but will commonly be pursued in the future of WPI.

### ***Live, Classical Style Audio Capture***

The first example is the cast recording of *Witchwife: A Requiem for Susannah Martin*, a musical theater piece by Professor John Delorey. I am the chief engineer and producer on this album. It was recorded with a live, classical recording technique. For all of the music, I used a pair of cardioid small diaphragm condenser microphones configured in an ORTF pattern, as well as a spaced pair of omnidirectional small diaphragm condensers. An ORTF pair is when two cardioid mics are spaced 17cm apart at an angle of 110°. This technique was developed around 1960 as a desirable way to recreate a live stereo image. As M-Audio explains in their M Pulse Newsletter, it was “Developed by the French national broadcasting agency, Office de Radiodiffusion-Television Francaise...this technique is intended to emulate the placement of ears in the average adult human head...The specified distance for ORTF makes wavelengths below about 500Hz effectively phase coherent. The time delays or phase incoherence above that frequency typically contribute to a sense of stereo separation, along with the perception of a pleasing open or airy quality.” (M-Audio, 2004)



I used the ORTF technique to make the stereo field as close as possible to what the live performance sounded like, because the live sound of the music was very affective in conveying the emotion of the show.



**Photos 15-16: Central ORTF and Spaced Omni Pair for Witchwife Capture**

When saying that this project was approached with classical techniques, I mean everything is captured live and post-production consists of splicing the best takes together, doing some equalization and perhaps adding a slight reverb. This style project calls for the music to be as close to perfect as possible at capture. It is necessary that the room ring and act as a reinforcement instrument.

From a talent side, the rule when going into any recording project is for the music well rehearsed. This comment may seem obvious or odd, but this becomes particularly important with a live-style capture of an ensemble. Errors made by one part of an ensemble become extraordinarily difficult to fix in post-production. Much of the post work on this project includes creating a pleasing stereo image with the two close mics, two spaced mics, and the roles of the Narrator and Town Crier. In

addition, EQ, reverb, limited compression will be necessary along with splicing the proper takes together.

The cast for the recording consists of much of the same principle cast from the Actor's Church production in Covent Garden, London, during E Term, 2009. There are also members of the campus vocal chamber ensemble, Vocal Performance Lab, as well as professionals hired for some featured solos and the roles of Narrator and Town Crier. I am pleased with the outcome of this project and am looking forward to the final release this year.

### ***Multi-track Audio Capture***

Capture and production techniques are very different for live, classical style recordings and multi-track recordings. An example of a multi-track project I completed was for Simple Harmonic Motion's (SHM), WPI's male a cappella group, album *Vital Sines*. This project was incredibly different than, but every bit as rewarding as the *Witchwife* project.

During much of the school years of 2007-2009, I was chief engineer and co-producer on SHM's album release, a project incredibly different than, but every bit as rewarding as the *Witchwife* project. I worked with engineer and producer John Clark, and split time between his studio (CB Productions) in Jamaica Plain, MA, and the Alden studio space. An equipment list for CB Productions can be found in Appendix G. The album was a popular music album recorded with only voices. Every voice of the group was isolated for every song. This technique is used in order to be able to effect each voice.

In live ensemble recording, you focus on rehearsing the sound of the group together, achieving a good balance, and letting the space act as a reinforcing instrument. While in multi-track recording, you use each voice as its own instrument, and affect each voice, mixing each voice to achieve a balance.

When we started work on the album, we recorded in the Alden studio with angled baffles, and an acoustic blanket draped over top. This achieved a fair isolation of the voice. However, we still needed to battle with the room and all of the external noise.

Therefore, most of the work on this project was done at CB Productions' studio space in Jamaica Plain. These facilities had two isolated vocal booths so the voice more successfully isolated in these booths and two takes could be recorded at simultaneously because of the two booths. This particular studio is a repurposed and acoustically treated attic. The rooms were not specifically designed as isolation booth but isolation and the desired acoustic were still well achieved. All takes were recorded with large diaphragm condensers, including the MXL 990 at WPI as well as various Neumann and Blue microphones in Jamaica Plain. Shock-mounts and pop filters were also used to keep excess noise and sibilance.

In addition to being an engineer on this project, I was also a producer. I really enjoyed being a part of the post-production process. The stereo image becomes much more complex when working with so many tracks. Effects used on takes included EQ, compression, reverb, delay, distortion, flange, and chorus. A

tremendous amount of layering was done on top of the group's arrangements, and all background takes were doubled to create a thicker, fuller sound.

This project was very successful and well received by the group, the campus, and the college a cappella community. *Long Train Runnin'* from *Vital Sines* was selected as a track on the *Voices Only 2009* a cappella compilation CD and different tracks from *Vital Sines* have received air time for on 88.9 WERS Boston, Emerson College Radio.

## **Practical Solutions at WPI**

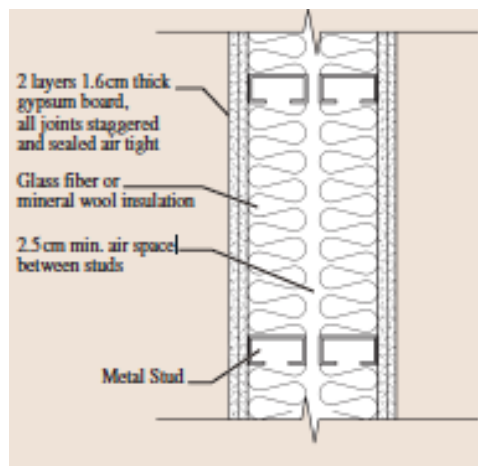
In order to fulfill the needs for a quality recording setup at WPI, the recording spaces need to be addressed. In my research, I have found that the best spaces for recording are purpose-built. Regardless, there are key elements in any studio design. I will discuss these key elements in proposing new facilities for WPI.

### ***Key Elements in Room Design***

As mentioned in the observed spaces section, one element of a studio is to avoid parallel surfaces. In a space, sound reflects off all surfaces, before and after it reaches the ears of the listener. Parallel surfaces should be avoided because they create what are called flutter echoes, which is when sound reflects back and forth off of the same parallel surfaces, along the same path. This causes phase addition of the original sound and its echoes in an effect known as comb filtering, diminishing the frequency spectrum of the initial frequency spectrum. The Springer Handbook of Acoustics explains, "In any case, the flutter can be avoided by simple absorptive or diffusive treatment of at least one of the opposite reflective surfaces...Besides, if it is possible to change the angle between the opposite walls just by a few degrees (3-5°), the problem will also disappear." (Rossing, 2007)

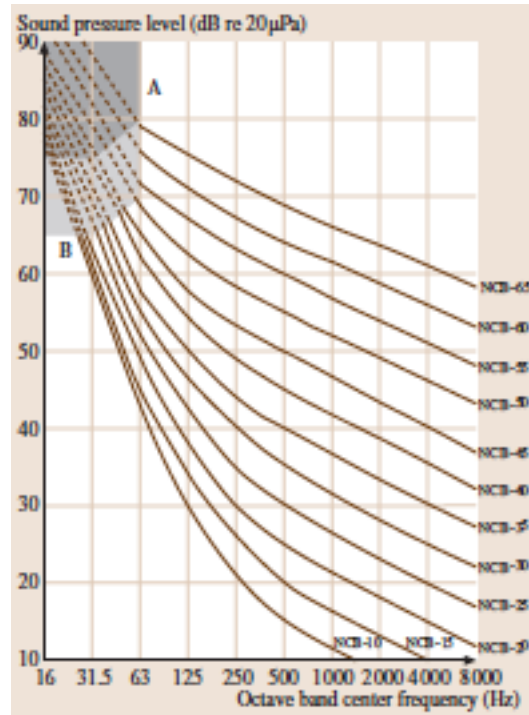
For the best acoustical environment, rooms should be designed as a room within a room, or, "box within a box," meaning that the walls of the room should not be outside walls, and that your room should essentially be supported within another frame, with highly absorptive, springy material between the frames to absorb any vibrations on the outside structure, as well as any external noise, such as motor vehicle traffic, planes, and mechanical equipment. Many of staff members at studios

I have visited have stressed the importance of this structural design technique, including Dr. David Berezan at Manchester University's NOVARS, and Joe Leach, owner of Cowshed Studios in northeast London. This technique drives down the noise criteria curve (NC or NCB), decreasing external noise and vibration. The Springer Hand book of acoustics shows this "double wall technique:" (Rossing, 2007)



**Figure 2: Springer Handbook's "Double Wall Technique"**

Noise criteria curves were developed to create benchmarks for testing ideal and typical noise levels in different spaces. According to the Springer Handbook of Acoustics, "sensitive listening spaces," such as recording studios or concert halls typically should be lower than NC 20, whereas theaters and churches should be under NC 25. NC 20 would be a good goal for a live room and a control/listening room at WPI. (Rossing, 2007)



**Figure 3: Noise Criterion Curves**

Any sound existing in the “A” space can create serious vibrational noise, including rattling of fixtures within the structure. Sound in “B” creates lower level vibrational noise. (Rossing, 2007) Being aware of acoustical considerations when designing new audio facilities can help in minimizing these vibrations.

Another key element, in addition to reducing the effects of external noise is to reduce noise inside your structure. Much of internal noise comes from electrical equipment, machines, heating ventilation and air conditioning (HVAC) systems, and plumbing.

To take care of noise from electrical hum, there should really be a soundproofed “Machines Room” to store all electronic devices that add noise to your space. A fine example of this is in Manchester University’s NOVARS research

building. Electrical noise is especially a problem in control/listening rooms and studios. Placing as many electronics as possible in the machines room can reduce this noise.

For HVAC and plumbing noise, much of the problem is with the units vibrating in their enclosures, causing, in many cases, noisy hums throughout the structure. Dr. Berezan recommended putting compressors, heaters, air conditioning units, etc. on spring supports and pads, to reduce vibration, or to use chilled beams like NOVARS. Joe Leach from Cowshed Studios recommended using a fan with the duct work, and a “silencer”. He built his own duct silencer using a small plasterboard box with gravel insulation between the box and the duct. He said this works extremely well for him. The bottom of this duct can be seen in the photo below:



**Photo 17: Base of Duct “Silencer” at Cowshed Studios**



The Springer Handbook recommends using partitions between ducts, and sealing ducts and pipes with permanently resilient sealant. (Rossing, 2007) The approach with much of this noise seems to separate and isolate the items that cause the noise.

The last of the key elements in room design for a live room and a control/listening room is to choose building materials carefully. For example, wood is a material that allows sound to reverberate relatively easily, but not as much as stone. Upholstery on seats is another consideration. Fabric in general is very absorptive.

### ***Live Space Proposal: A Thorough Utilitarian Design Approach***

For the purposes of my proposal, I am focusing on what is really needed at WPI. After talking and working with much of the Music Division staff I have concluded that in addition to there being no truly desirable room to record in on campus for any ensemble; there also is not a room with a desirable acoustic for performance. If WPI were to build a new performance hall, there would be much consideration over the ideal venue as well, because the ideal hall for a choral concert is not the ideal hall for a jazz ensemble concert or a musical. Thus, I believe the best solution is to create a utility space so all can perform and record there.

While contemplating solutions for our various types of recording at WPI, I could not help but think about what Hugh Robjohns at *Sound on Sound Magazine* said, or what the designers from Blueprint Studios did with their knowledge of the nature of sound and room acoustics. As I mentioned in a previous section, Mr.

Robjohns said that for versatility in recording projects, I should not be as focused on the equipment so much as the live space for the recording.

I believe this to be the case not only for versatility in the kinds of recording projects you can perform in the space, but also in the nature of the performance in the space. Building a hall with a variable acoustic, including large mechanical three-way traps similar to the traps at Blueprint Studios seen in **Photo 10**, as well as potentially removable/retractable seats, and perhaps retractable divider(s) in the room to allow for ensembles of different sizes would be the practical utilitarian approach to building a new hall.

For a concept for a new multi-purpose facility at WPI, the new EMPAC facilities at RPI are a great model. The live space is constructed mostly with wood and traps of different kinds including fabric ceiling traps. EMPAC is a great model, because it was built at another technical school with some of the same needs as WPI. While the main concert hall in EMPAC does not have the treatments I advised for a new hall at WPI, it has several other treatments, some of which are mentioned above. It is really the entirety of the facilities at EMPAC that is so impressive. In addition to their concert hall, there is a theater with a seventy-foot flytower with “computer-controlled rigging...anything – props, projectors, or people – can be flown (and controlled by computer in real-time, a first in theater technology) throughout the stage space. The theater is as quiet as a recording studio and has the technological infrastructure of an HD video studio. The low stage allows for tangible immediacy between audience and performers.” (Rensselaer Polytechnic Institute,

2009) If a new full-size theater space is needed at WPI, a facility like this is also a good model. Under the concert hall is the theater, and studio facilities. Patches direct from the hall would be ideal to record ensembles. Their recording and production studios are ideal for an academic audio environment: “Both studios are equally quiet and highly networked, rewarding audiences and supporting experimentation by artists and researchers alike.” (Rensselaer Polytechnic Institute, 2009)

EMPAC manages to have all of these facilities and keep everything at a reasonably low noise criterion: “EMPAC embodies a number of design and construction innovations. An extraordinary baseline of quiet has been achieved through acoustic separation—literally a space between the walls and floors of each venue—to prevent conduction of noisy vibrations. To further cushion vibrations, parts of the building sit on springs embedded in the foundation. The entire building is secured by 215 cable anchors that reach deep into the hillside’s bedrock, making EMPAC one of the most seismically secure buildings in the region.” (Rensselaer Polytechnic Institute, 2009) With all of these capabilities, RPI students are now capable of using these facilities for performance or research in a world class space. “EMPAC’s superb venues provide opportunities for research that surpass those of most other media research centers.” (Rensselaer Polytechnic Institute, 2009)

While building a facility with this purpose would be fairly expensive, I believe it makes the most sense for WPI, because it avoids having to build a new facility for campus ensembles and groups to perform in and one for them to record in. It would

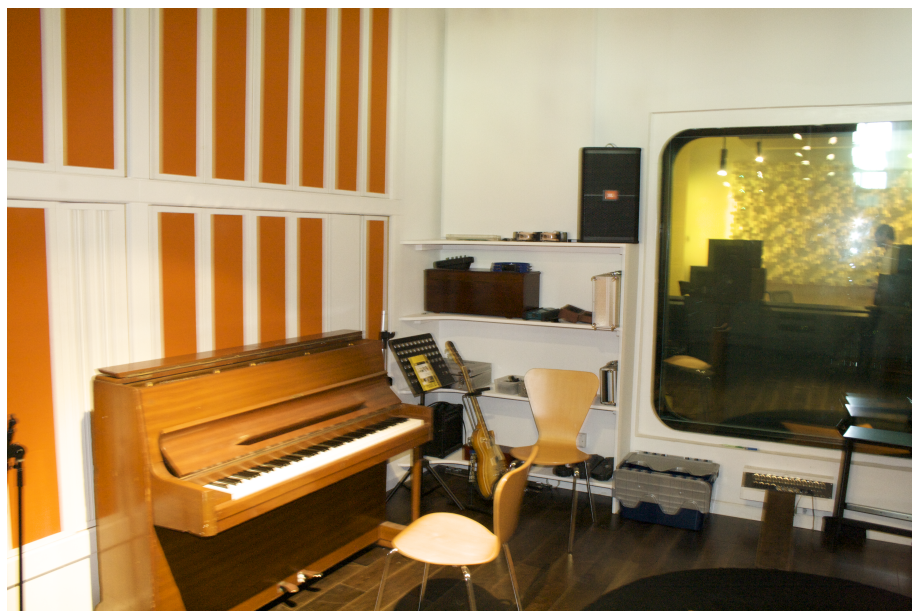
satisfy the campus ensembles' technical and performance needs, as well as provide students with a great facility for research and work in audio engineering, an academic interest that several current and prospective students have, with no current way to satisfy on campus.

For a live space within a new facility, I would use EMPAC's main concert hall and the Millenium Centre's recording space as model, while making the hall a bit more versatile with variable acoustics would be ideal. I would use Manchester University's model for studio facilities, especially with regards to thorough design and consideration of networking and precautions made to prevent noise. I also liked Alchemea's design of a control room with visual windows to two small live rooms. I would probably suggest a recording studio with windows into two isolation booths, and one small live space. The isolation booths would allow for ease of multi-track recording, like the work I did with SHM at CB productions, where we could track multiple guys at once. A great example of an isolation booth would be the booth at Cowshed Studios:



**Photo 18: Isolation Booth at Cowshed Studios, London**

The booth just needs to be a small room with highly absorptive wall surfaces, and a line of sight to the control room (via a large angled window). The small live space would be ideal for small jazz combos and rock bands. A great example of a small live space is the one found at Blueprint Studios:



### **Photo 19: Small Live Space at Blueprint Studios, Manchester**

I would also include a few workstations, classrooms and laboratory facilities for additional academic class space.

#### ***Equipment & Software Proposal***

The main questions that need to be answered in proposing equipment for the future of audio engineering at WPI have mostly been discussed already in this paper. *Do we use predominantly analog or digital equipment? What kinds of projects will we be recording?*

The analog versus digital debate has been going on for a long time, and I do not believe it will stop any time soon, simply because people have done vast amounts of exceptional work with both formats, and it generally comes down to a personal preference. Fred Kindt at Blueprint Studios explained it really well to me. He said that educational institutions often teach on multiple formats, in order to thoroughly prepare the student for a career in an industry where everything is always changing, and everyone has personal preferences. Institutions that do not have the resources to teach on multiple formats can often take the time to find the best value for them. However professional studios, in order to attract and keep clients' interest, need to adhere to current industry standards, and the standard now is certainly digital equipment with digital audio workstations (DAWs) like Digidesign's Pro Tools and Apple's Logic.

To prepare students for the industry, WPI should use a principal digital console. At the moment, the 003 is sufficient, but should consider a console with

more channels and more capability, like the Digidesign ICON console, with a Pro Tools HD setup, or the Digidesign 192 Interface. I also recommend a small analog board like a Euphonix, or a Soundcraft, to teach students both analog and digital recording.

While I see these consoles as ideal for preparing students, the current 003 is an acceptable console that could use some ADAT expansion in favor of more immediate upgrades of other equipment that is far inferior. This inferior equipment includes microphones and production software/DSP equipment.

In addition to this equipment, to address the recording club's mobility issue (recording shows outside of Alden Hall) they should take Hugh Robjohns' advice and acquire a mobile digital hard disc recording device, so all audio can be dragged into Pro Tools on the main studio computer.

Ensembles like large choruses, full orchestras with significant dynamic ranges, jazz ensembles, chamber groups and a cappella groups conduct recordings all the time, all have different needs for recording. Main concern is obtaining microphones to affectively mic these ensembles. As I did with the recording space, I am considering the most utilitarian approach and recommending as many multi-purpose microphones as possible.

For studio vocal microphones, I recommend large diaphragm condensers like a Neumann TLM 103, a Neumann M149 tube microphone, and a Rode NT1-A. These microphones would be stunning for multi-track vocal studio mics, and would satisfy

all a cappella recording microphone needs, as well as combos and bands with multi-tracked vocals.

A microphone like the Electrovoice (EV) RE 20 would be a very versatile cardioid dynamic mic great for close-miking brass, woodwinds, and many other instruments in a multi-track recordings. Investing in a few of these, for jazz ensemble recordings and small orchestra/band recordings would be a good plan.

Also, a few ribbon microphones like the Audio Engineering Associates (AEA) R88 would be incredibly versatile. Ribbon mics in general use what is called a figure eight pickup pattern that picks up sound from the front and back of the element, but not the sides. According to AEA, the R88 was “inspired by the design of the venerated RCA 44. The R88 is optimized for natural frequency response and precise stereo imaging. It's large ribbon geometry design inherits the extended bass of the classic R44 and critically acclaimed R84 microphones. The clean and smooth treble of the R88 is very flattering to complex tones such as woodwinds, strings, and cymbals. The R88 is an excellent orchestral and choral recording microphone, and shines on studio applications such as horn sections and drum overheads as well.” (Audio Engineering Associates, 2006)

This microphone would be perfect for a number of miking needs, and I believe a pair would be ideal.

A DPA 3521 compact stereo cardioid pair are perfect for “low profile mounting directly inside a piano. With the XY/ORTF holder, the kit is also exceptional as a compact stereo pair for applications such as overhead for drums,



horn or string sections, choirs, main or additional spot pair for small or big acoustic ensembles. The complete kit is supplied in a sturdy carrying case and includes the combination XY/ORTF holder, a shock mount, 2 gooseneck mounts and 2 magnet bases for mounting on metal surfaces and windscreens.” (DPA Microphones, 2009)

Additional microphones would include a drum mic kit like the Shure PGDMK6-XLR, a six mic set with drum mounts to record every drum multi-track, for jazz combo, miscellaneous percussion and rock-style drum kit recording.

The last addition under microphones is actually for quality microphone preamps, which would be highly recommended with this list of high quality microphones laid out. The AEA R88 should have its own ribbon microphone preamp, as designed by AEA. This preamp is designed specifically for ribbon microphones by AEA, and has two channels, perfect with a pair of R88s. As for a preamp for other microphones, going with a tube preamp like the Avalon Vt 737sp Microphone Pre-amp/Compressor/EQ, and an eight channel like the Oram Sonics Octosonic would be best.

All of these recommendations are based off of the engineers with whom I have spoken and worked. I worked with the microphones on this list, or comparable microphones, with many of the same manufacturers. With these microphones and preamps, I believe every regular scenario for recording at WPI would be covered, and captured impeccably well.

The final focus on equipment needs is in production. While nothing makes production easier than perfection during capture, even if students are well equipped

with high-end microphones and capture techniques, perfection rarely happens and post-production is a necessary part of any finished product. With the proposal being focused on a digital console and with the standards in the industry being computer DAWs, I recommend software production “suites” that contain multiple DSP and production tools.

Through my experience working with various producers, I recommend the Oxford EQ, Dynamics, and Inflator, as well as the Oxford Reverb. These in addition to the Waves Gold Bundle are digital signal processing (DSP) software processors with production and mastering tools including equalization, reverb, compression, flange, de-esser, and delay. These software bundles replace (and often model and expand upon) what used to be rooms full of rack-mount DSP hardware.

Antares Auto-Tune, and Celemony Melodyne Editor with Direct Note Access Technology are tuning software packages that allow you to shift pitch and tune notes and have capability to edit note attack, length, rhythm, and decay. The direct note access technology is very new and is praised as being able to use an algorithm to separate polyphonic sound into each individual note, each which can be shifted and manipulated in the editor.

Reason is one more piece of software I highly recommend for the studio. It is great for working with synthetic sounds, including synthesizers, samplers, loopers, and effects like arpeggiators and vocoders. This would be of high value for students working with electronic music. I recommend using all of this software in conjunction with Pro Tools for production purposes.

I recommend all of this production software after using each element I suggested in various studios and locations. Going from an impeccable capture to an impeccable production stage will be easy with this equipment.

## **Future Audio Environment at WPI**

I have spoken with several current WPI students and graduates who say if there was an academic program like audio engineering they would study sound recording technology/acoustics. I have given tours of Alden Hall and the Music Division facilities on multiple occasions, showing prospective and expected students the recording studio facilities, and explaining the recording club and my independent, individually-designed major. Many of these tour-goers specifically asked to see recording studio facilities and expressed interest in developing majors similar to mine as well as an interest in the Recording Club. I hope that the future of audio engineering at WPI becomes two-fold: extra-curricular and academic.

I am very excited about the Recording Club's progress. For a group that started with very little, they are now a recognized class I organization, and just passed an SFR through SGA for some new equipment and an operating budget for the year. A full list of the equipment they are currently acquiring with the SFR money can be found in Appendix H.

I approached my ID major as a truly inter-disciplinary program and I believe this is the best and most thorough way to study Audio Engineering and Production. There is a physics component in acoustics and the nature of sound. There is an electrical and computer engineering component in the integration and design of audio electronics. There is a music component, as engineers and especially producers need to have well trained ears. They really should be musicians first and fundamentally before producers. Then there is a need for a higher-level focus

specifically on elements of the industry. The proposal for my major, including a proposed curriculum list can be found in Appendix I.

Because of the significant interest in audio engineering among students and prospective students, I believe students should have an option of pursuing a degree in Audio Engineering and Production without having to go through the ID major process. While I loved the opportunity of forming my own major and designing my own curriculum, many students are not even aware of its existence and should not have to go through this process to receive this degree. Not only is there an interest in this kind of program but WPI already possesses faculty qualified to teach classes in nearly all of the curriculum. I was able to design my own curriculum and all of my classes were taught by WPI professors. Not only is this an engineering field that many young people study, but, like in several other engineering fields, there are fantastic opportunities for WPI to conduct cutting edge research, and attract more students.

However the audio engineering environment at WPI carries on into the future, through a heavy extra-curricular only interest or a new catalog major, the important task is to acknowledge the interest among students and do everything possible to help them pursue these interests.

## **Conclusion**

When I came to WPI, I was quite surprised they did not have true audio recording or production facilities on campus. Through working independently in my Individually-Designed major in Audio Engineering and Production, personal experience in the audio industry, and research of various audio facilities and venues, I have been exposed to an industry with a future that has a plethora of opportunities for research and work. I wish to see WPI foster this opportunity. This project is a proposal for a future audio engineering environment at WPI; including what I believe to be the best plans for audio facilities and equipment as well as advice to encourage an Audio Engineering and Production major. This proposal is based upon extensive amounts of research in the audio field in both the profession and in academia.

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## **Appendix A: Interview Questions for Industry Professionals**

What is your job here, and your job title?

How long have you been in the industry?

What kind of projects do you typically work with? Instrumentation? Live/multi-track?

What is the main nature of the studios here?

What is the staffing like? How are jobs divided up?

What software/hardware do you typically work with? What do you think are its strengths and weaknesses? Is there any interface that you prefer over another?

Why? What software do you recommend for a studio to start?

Have you done live location recordings and studio recordings?

Who designed the studios here?

What room(s) do you mainly work in here? Are there any treatments or design considerations that make that room desirable or undesirable to work in?

Is there any room that you prefer to work in (studio or live)? Where is your favorite place to capture recordings? To work on production? Why do you like the room?

Do you have an isolation booth here? What design elements do you believe to be important in an isolation booth?



## **Appendix B: Interview Questions Revision for Academic Interviews**

What is your job here, and your job title?

How long have you been in the industry?

What kind of projects do you typically work with?

Do you do any audio recording or production?

What is the main nature of the Center for Digital Music?

What is the staffing like? How are jobs divided up?

What software/hardware do you typically work with? What do you think are its strengths and weaknesses? Is there any interface that you prefer over another?

Why? What software do you recommend for a studio to start?

Who designed the facilities here? When?

What room(s) do you mainly work in here? Are there any treatments or design considerations that make that room desirable or undesirable to work in?

Is there any room that you prefer to work in (studio or live)? Where is your favorite place to capture recordings? To work on production? Why do you like the room?

Do you have an isolation booth here? What design elements do you believe to be important in an isolation booth?

## **Appendix C: Critical Listening Observations of Live Performance Venues in London**

Impropera – May 10, 2009 - Leicester Square Theatre

Impropera refers to Improv + Opera. It was quite fun! I believe the host of the show put it best: “We took two incredibly underappreciated, unpopular art forms and combined them in the hopes that we would strike gold!” Leicester Square Theatre opened in 2002 with 420 seats. The room was treated with carpet floors and what seemed to be thin wood panel walls. The sound in the room seemed to be absorbed significantly, and some of it seemed to linger in the sides of the theatre near the wood panelling. I believe that the carpet played a large role in the heavy absorption in the room. When the show first started, the host started to speak, leading Professor Delorey to ask me, “Is he miked?” In fact the only live sound reinforcement was for the electric keyboard, but I thought it interesting that Professor Delorey questioned about there being a microphone. I believe this effect was created because of the apparent directionality of the sound. Again, in the main area of the house where all of the seats are located, the sound was heavily dampened, however on both sides, especially in the front corners of the theatre, the sound seemed to ring more. Now, in a hall where you have solely reinforced shows, having the house carpeted and having other absorptive materials might not be as big of an issue, however, I imagine that Leicester Square Theatre has a mix of both reinforced and non-reinforced shows, and that much carpet heavily affects the acoustic of the room. At no point did I believe this effected the balance, and overall ability for the observer to hear what was going on, however I think if the singers were not as strong and/or the players were not playing loudly, overall sound level

may have been an issue. On top of the wood panelling on the sides of the theatre, the only other potential treatments I noticed were twelve small domes cut out of the ceiling above the seats (and carpet). Overall, I would rate the Leicester Square Theatre as a medium-live reverb with some inconsistencies.

#### The Sixteen 30<sup>th</sup> Anniversary Concert – May 12, 2009 – Queen Elizabeth Hall

The Queen Elizabeth Hall is one of the halls at the Southbank Center. The South Bank Center is quite an interesting space. The halls are rather crude from the outside, as they were built at a time when certain appearances were not affordable and the interior was renovated at a later date to improve the acoustics. The space was designed as what looks like egg crate shapes of concrete, achieving a good separation from external noise, but I believe it took a lot of creative acoustical treatment to get it to where it is today. I have to say that the treatments that they performed have created wonderful results! There were some reflective materials on the ceiling and bottoms of the walls (concrete) as well as what looks like concrete air ducts up the ceiling. Sound was pleasantly ringing in the space, and I enjoyed the performance of the ensemble, The Sixteen. The ensemble is a combined choir and orchestra. Their program was one treat after another: Purcell's *Chacony in G minor*, *Praise the Lord O Jerusalem*, a new edition of Agostino Steffani's *Stabat Mater*, and Handel's *Dixit Dominus*. A wonderful performance in a very well treated room made for a delightful aural experience.

#### Romeo and Juliet – May 13, 2009 - Shakespeare's Globe Theatre

Going into the project, I knew that I would certainly be observing some diverse venues in London, and surely, this is a prime extreme, being an open air theatre. I really feel this one could not be missed. I had been to the Globe once before, but

never for a production, and this one was very well done! One thing very obvious from start to finish was the importance of the actors projecting their voices. The cast was quite good. Romeo was fun and playful, Juliet was young and sick for the performance, but a strong actress. As for the space: there was a lot of wood and open space, obviously no sound reinforcement. It was nice when actors could project, but there was a flip side to that as well (again, poor Juliet was sick). Music was worked very well into the show including small orchestra pieces and vocal chant. Another component that really factored in with this theatre was that it is an open roof, so needless to say there is a lot of outside and environment noise from the Thames, airplanes overhead, etc.

Choral Evensong – May 14, 2009 – Westminster Abbey

After a tour of the Abbey, we stayed for Evensong, and got the opportunity to sit between the altar and the choir in the quire. The acoustic in the building was impressive to me, because, although it is a large space with a lot of stone for sound reflection and reverberation, the sound managed to stay very clear. At some point, I would like to sit outside the choir to hear how the sound reacts with the rest of the space, as being in the quire obviously gave me quite a short distance from the source. The quire itself is made of wood, and other soft, more absorptive materials, so I believed this helped to keep the sound clear, and not allow it to get very muddy. There is also a divider between the quire and the nave that does not allow the sound to easily and directly reach the nave. I believe this acts as a baffle in the space.

### Choral Evensong – May 15, 2009 – Saint Paul's Cathedral

It was rather fascinating to go from Evensong at Westminster Abbey one day to Evensong at Saint Paul's the next. The choirs sang some of the same music (Leighton Responses), and I even had a similar vantage point in terms of distance from the source, but hearing these two spaces essentially “side by side” showed what a drastically different sonic experience they are! St. Paul's, again is stone, but significantly larger than Westminster Abbey. There is also a large stone dome in the center, in front of the quire, and a long nave all open and connected. There is no divider, like at the Abbey. Sitting in the quire here gives the listener an idea of how large and reflective the space is, because you are so close to the source that you can distinctly hear when the sound leaves the source, followed by a clear echo of the initial sound. This is not a simple reverb, it is a long enough reverberation time to present a clear echo of short words and phrases from the vantage point of the quire.

### The Harp Consort – May 16, 2009 – St. John's Smith Square

This concert was part of the Lufthansa Festival of Baroque Music at St. John's Smith Square. The church was designed with four square corner towers, and is box-shaped. Inside, there is a large barrel vault in the center, and there was a large fabric curtain up behind the stage. There were several wood surfaces, and the space had a fairly good acoustic, though I feel like there were too many surfaces absorbing the sound, because it did not ring quite as much as I would have liked. Part of this may also be some of the music played by the Harp Consort. The ensemble was very entertaining, playing a lot of English baroque dance music, while really putting on a show with lyrical readings, singing, dancing, and dynamic music. I believe what was most enjoyable about the music was all of the baroque instruments they played including an early harp, lute,

guitars, viol, violin, shawm, early flute, bagpipe, hurdy-gurdy, and miscellaneous percussion. They put on a great performance in a good space.

#### BBC Radiophonic Workshop – May 16, 2009 – The Roundhouse

To revisit the thought of there being quite diverse performance spaces in London, I must say that the Roundhouse in Camden Town is definitely one of those fascinating venues. The building was originally built as a switching station for trains to turn around, at a time when trains could not move backward. The building is essentially a big wooden dome, which has been expanded upon and treated over time. It was a popular concert venue in the 1960s, hosting bands like The Jimi Hendrix Experience and the Doors. The building shut down for some time, and reopened recently. They now host regular concerts, sound installations, and small music festivals. In fact, the BBC Radiophonic Workshop were the final artist during an electronica music festival entitled *Short Circuit*. The Radiophonic Workshop was a group of experimental/electronics musicians hired by the BBC in the late 1950s to make sound effects and electronic music. The group has been incredibly influential for electronic music as we know it, and it was so much fun to see them perform.

The space was interesting to listen to. It was a loud show, using arrays of loudspeakers in front left and right, as well as stacks in the rear left and right. This allowed for a pleasing experience in the center of the dome.

#### Kaxan String Quartet – May 19, 2009 – St. Martin in the Fields

I have been hearing about St. Martin in the Fields for years. I have listened to concert broadcasts and recordings, and I was excited to finally hear a concert in the space...and what a fantastic space it is! It is not an overly large space, but beautifully designed. It

has a large barrel vault in the ceiling, Corinthian columns down the sides, and a lot of wooden surfaces. In general, wood allows a fair amount of reverberation without being too much in a space this size, and I will say that St. Martin in the Fields certainly ranks high on the list of pleasing acoustics I have observed in London. The sound was similar to St. John's Smith Square, but fuller and brighter. The quartet put on a strong performance, especially for a group that is relatively young. I enjoyed the unorthodox instrumentation of two violins, viola, and violoncello, especially with the dynamic of the pieces they performed: Mozart's *String Quartet in G Major* and Shostakovich's *String Quartet No 7 in F sharp minor*.

Rob Hughes – May 20, 2009 – Cafe in the Crypt – St. Martin in the Fields

After going to a performance at St. Martin in the Fields, I was certainly intrigued that they hold concerts in the crypt. There are concerts in this space all the time, including weekly jazz nights. On top of the music being great, I would like to comment on an interesting sonic experience during the performance. The crypt has several brick columns with low vaulted brick ceiling sections between each column. Sound was reverberating for a long time in the space. Not only was the sound taking time to decay, but I could hear the effect of the sound reflecting off the brick crests and down the arched vaults to the columns. I walked around the crowded room, and noticed the sound of certain instruments being louder near certain columns. I can only make an educated guess and say that instruments with sound firing in a more prominent direction, such as saxophone, and the cabinet of the guitarist were creating this effect when the sound centered its reflections along the vaults of the ceiling.

Choral Evensong – May 27, 2009 – Saint Paul's Cathedral

This time, I sat under the dome, and I was only there for the end of the service, but it was

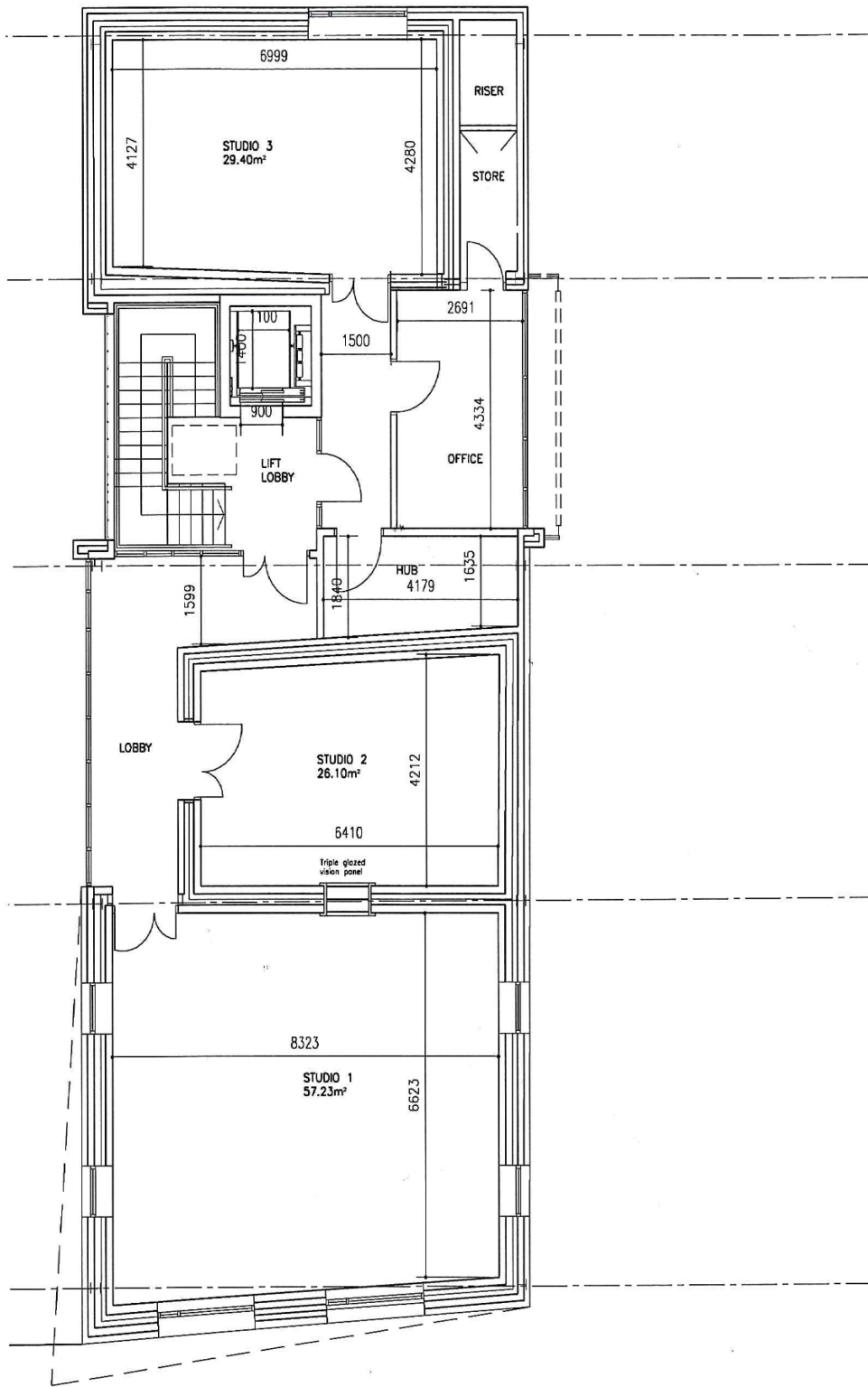
fascinating to hear the sound react in the space from a completely different vantage point. It is interesting, because in both cases I was able to perceive how large and reflective the space was, however in completely different ways. When sitting in the choir, the observer is so close to the source that one could really get an idea of the reverb time in the space, because one could quite distinctively hear the original sound and its echo. While sitting under the dome, however, the initial sound does not reach the ears of the observer as quickly, and, while swirling in the massive stone dome overhead and traveling the vast extremities of the cathedral, bouncing off the stone and returning reflected sound to the ears makes it difficult to discern between the initial sound and its reverb or echo. Clarity especially becomes an issue in the middle of musical phrases, where rests in the music have not allowed the listener's ears to adjust before hearing the most recent sound to reach the ear.



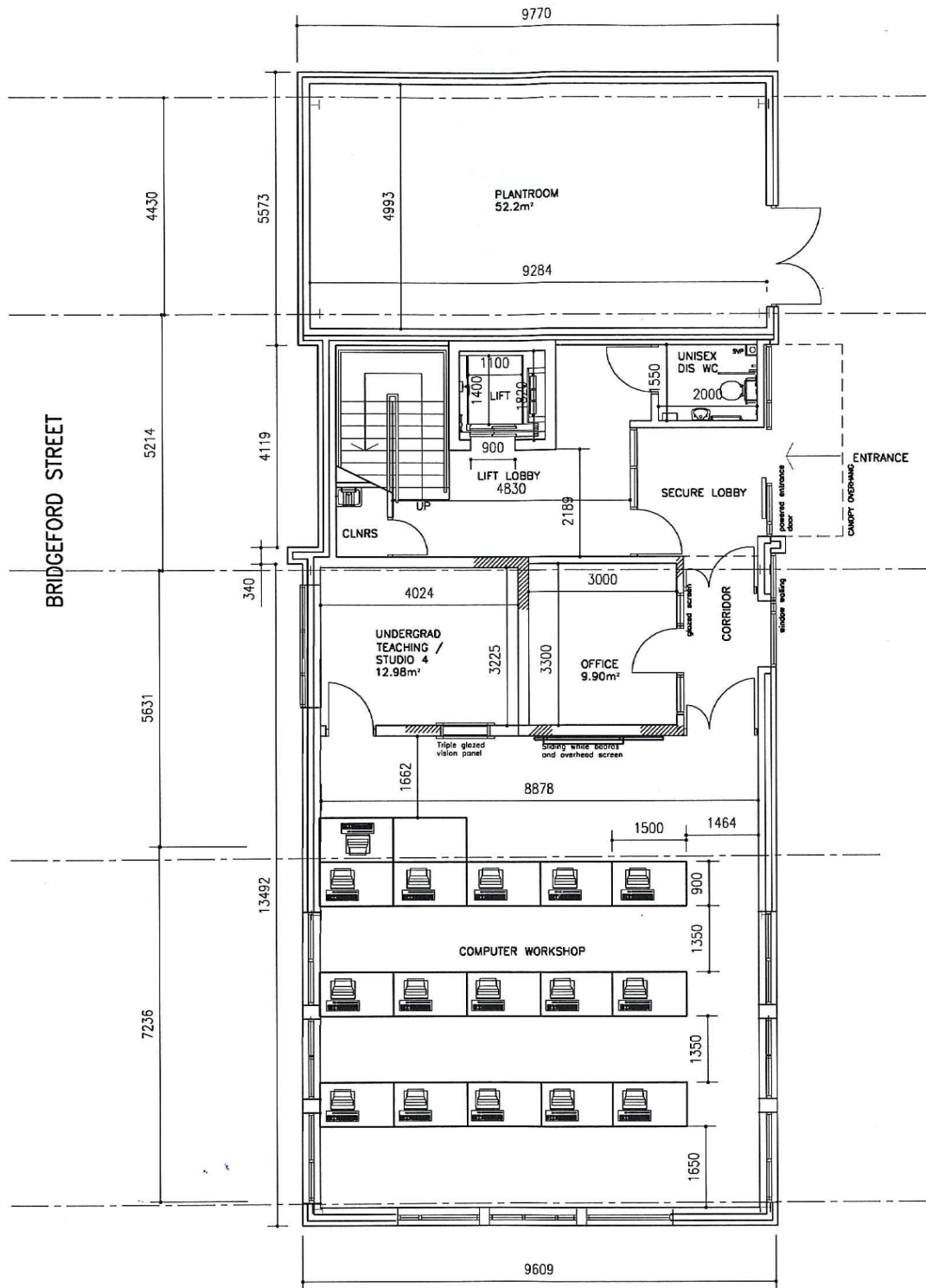
## Appendix D: Architectural Layouts for NOVARS Facilities at University of Manchester – Manchester, United Kingdom

A	STUDIO 4 OMITTED AND PLAN AREA REDUCED FROM 440M <sup>2</sup> TO 400M <sup>2</sup>	SK	07/-05
ref	revision	drawn by	checked by    date
<p>project</p> <p>The University of Manchester Electro Acoustic Suite</p>		<p style="font-size: 1.2em; font-weight: bold;">Cruickshank and Seward</p> <hr style="border: 1px solid black;"/> <p style="text-align: center; font-weight: bold; letter-spacing: 0.5em;">ARCHITECTS</p>	
<p>title</p> <p>Option 4 B Ground and First Floor Plans</p>		<p>Barclay House 35 Whitworth Street West Manchester M1 5NG</p>	
CAD file ref	drawn by	date	job number
<b>5569</b>	<b>GEB</b>	<b>25/07/05</b>	<b>5569</b>
status	checked by	scale	drawing number
<b>stage C</b>		<b>1-100</b>	<b>C 17A</b>

Tel: 0161 236 6161  
 Fax: 0161 236 6259  
 E-mail: architects@cands.co.uk



First Floor Gross internal floor area  
197.00m<sup>2</sup>



Ground Floor Gross Internal floor area  
204.5m<sup>2</sup>

# Appendix E: Full Equipment List for Alchemea College of Audio Engineering – Islington, London, UK

## ALCHEMEA STUDIO FACILITIES (ISLINGTON)

## ALCHEMEA

### Studio One – EUPHONIX CS3000

Euphonix CS3000 digitally controlled analogue mixing console with 32 Active DI Boxes / 24 Automatable Multi-Dynamics Units and the Cube for surround mixing  
 Digidesign Pro Tools HD3 Accel with literally thousands of pounds worth of high end plug-ins (inc Sonnox & McDSP)  
 3 x Digidesign 96/IO converters and Sync I/O  
 Otari MTR 90 MKII. 2" 24 track tape machine  
 Apple Mac G5 & 23" Display  
 Apple Logic Studio (Logic Studio)  
 Custom designed Dynaudio main speakers  
 Genelec 8040A near-field monitoring  
 Yamaha NS10M near-field monitoring  
 Thule and SMA Amplification  
 Universal Audio UAD6176 Channel Strip  
 Lexicon 300 Digital effects processor  
 Lexicon PCM 80 Digital effects processor  
 Eventide H3000 D/SX Dynamic Ultra-Harmonizer  
 T C Electronics D - Two digital delay  
 Roland R880 dual digital reverb  
 Vintage Roland SVC 350 Analogue vocoder  
 Ensoniq DP/4 Parallel digital effects processor  
 Aphex Type C Aural exciter  
 Francinsteel stereo enhancement system  
 Roland A880 MIDI Patchbay  
 Tascam DA30 Mk II DAT machine  
 Marantz CD5000 CD player  
 Large, day-lit, air-conditioned room

### Studio Two – SOUNDCRAFT 1624

Soundcraft Series 1624 mixing console  
 Apple Mac G5  
 Digidesign 002 & Pro Tools LE  
 Dynaudio BMS & Yamaha NS10M monitoring  
 Quad / SMA amplification  
 CD player, Aiwa AD-F450 cassette deck  
 Lexicon LXP 15 digital reverb  
 Alesis XT digital reverb  
 Bel BF-20 analogue flanger  
 Deltalab ADM 4096 digital delay line  
 Audio & Design F760RS FET dynamic processor  
 EXR aural exciter  
 2 x Behringer MDX2100 (comp/limiter/gate)  
 Behringer XR2400 Autoquad - four channel expander / gate

### Studio Three – Programming Room

Soundcraft DC2000 with FLYING FADERS  
 Apple 8 core Mac Pro 2.8 GHz (4gb RAM)  
 2 x Apple 20" Cinema Display  
 UAD-2 Solo DSP card (all plugins included!)  
 Digidesign 002 Rack with Pro Tools LE

### Alesis AI3 ADAT interface

Genelec 8030A monitors & 7050A Sub Bass  
 Access Virus Classic, Nord Rack 2  
 Roland XV5080 (SRX Keys), MOTU Mid Express XT  
 M-Audio Radium 49 Controller Keyboard  
 Pro Tools LE, Logic Studio, Cubase 4, Ableton Live, Reason, Phat Factory, NI Komplete, Waves Diamond Bundle, Spectrasonics Trilogy  
 Lexicon LXP 15 Mk. II Digital reverb  
 Alesis Quadverb GT Digital multi FX unit  
 2 x Behringer MDX2100 composer compressor / limiter / gate, Behringer Virtualizer Pro Effects  
 Alesis MEQ230 two channel graphic EQ  
 Drawmer DS201 two channel filter gate  
 Deltalab ADM 4096 digital delay line  
 Aphex Type B aural exciter

### Studio Four – ICON 5.1 Cinema Dubbing Theatre

Large, air-conditioned sound to picture Post Production Dubbing Theatre with extensive quadratic diffusion to simulate a standard motion picture mixing environment.  
 Stewart THX certified acoustically transparent Cinema Screen with projection system.  
 Genelec 5.1 surround speaker system comprising of 5 Genelec 8040s and a 7070a sub bass management system.  
 Digidesign Icon Large Format Mixing Work surface featuring the following components:  
 16 Fader D Control with XMON and Surround Sound Panning option, AppleMAC DP G5 with Digidesign HD 3Accel, Sync I/O, 192 I/O, 96 I/O, Pre remote controlled preamps, Avid Mojo Video Capture & Playback system for Pro Tools with Media Station software. PAL Video ref generator.  
 High quality HD plug in selection optimised for post production examples being Vocalign, Sonic No Noise and Virtual Katy 2.  
 Sound effects library with over 7,000 FX.  
 DVD Player / Cinema seating for ten people.

### Studio Five – SSL G-series

Solid State Logic 4000 G series automated console (V G4.00)  
 Apple Mac Pro with Logic Studio  
 MOTU 2408 mk3 I/O  
 Acoustic Energy AE22-04 & Yamaha NS10M near-field monitors  
 TC Electronic M5000 Digital Mainframe FX  
 TC Electronic D2 24 bit Multitap Rythym Delay  
 TC Electronic M1XL 24 bit Multi FX  
 Lexicon LXP 15 Mk. II Digital reverb  
 Sony D7 Sound Processor  
 Aphex 204 Aural Exciter

## ALCHEMEA STUDIO FACILITIES (ISLINGTON)

## ALCHEMEA

### Studio Five – SSL G-series cont...

TLAudio 5013mk2 Parametric EQ  
TLAudio Ivory 5021mk2 dual valve compressor  
TLAudio Classic PA1 Dual Mic Pre  
LA Audio Quad Gates  
Otari MTR 90 MKII. 2" 24 track tape machine  
Tascam DA30 Mk. II DAT, Sony cassette deck

### Studio Six – PRO TOOLS HD TRAINING ROOM

2 x Pro Tools HD 2 Accel with  
Digi Pre Amps, Sync I/O & Midi I/O  
Digidesign D-Command control surface  
Digidesign (NEW) C|24 control surface  
Sony DSR 1800P DVCAM VTR  
Avid V10 & Avid Mojo AV Systems  
Black & Burst Generator & VTR  
Apple Mac G5  
Hewlett Packard Dual Proc PC optimised for Avid systems.  
LG 42" LCD 1080p True High Definition monitor screen  
2 x Dell 20" LCD Display & TFT Video Monitor.  
Mackie HR624 5.1 monitoring (with China Cones stands)

### Apple Training Room

10 x Intel 20" iMac computers running Pro Tools LE, Logic Studio, Ableton Live, Reason, Recycle & Final Cut Studio  
10 x Digidesign M Box  
10 x Audio Radium 49 MIDI controller keyboards

### Recording Areas

Room 1 - 225 sq.ft. (Daylit, Window to CR1)  
Room 2 - 150 sq.ft. (Daylit, Windows to CR1 & 3)  
Room 3 - 70 sq.ft. (Vocal Room / Cinema Link)  
Room 4 - 300 sq.ft. (Daylit, Window to Studio 5)

All live areas can be patched to any of the control rooms via a central patching room.

### Music Technology Workstations

6 x Apple 8 core Mac Pro 2.8 GHz (4gb RAM) +  
20" Apple Cinema Display  
6 x Digidesign M Box (Pro Tools LE)  
6 x M Audio Radium 49 MIDI controller keyboards  
Logic Studio, Cubase, NI Kontakt, Reason, Ableton Live  
UAD2 Solo Cards (includes every available UAD plug-in)

### Microphones

Over 60 microphones inc: Neumann (3 valve), Schoeps, Calrec, DPA, AKG, Shure, Beyerdynamic, Electrovoice, Sennheiser, Octava, Geffel, MBC, Sony, RCA, SE Gemini etc...

### Additional Equipment

Drum Kit, Congas, Guitar Amps, Fatar full size weighted MIDI keyboard, Pop Shields, Mic Stands, Cables, DI Boxes, Beyer Dynamic DT100 headphones, Akai S3000XL, Yamaha DX7, EMU Proteus 1000

### Mobile Studio & Media Pack

Diploma student's receive their own (to keep!)  
Apple 13" White MacBook (2.1 GHz), Digidesign M Box Mini (Pro Tools LE), M Audio Keyrig 25 MIDI controller keyboard, Rode M3 mic with stand, pop shield, XLR cable & blank media. SAC student's receive their own Digidesign M Box Mini (Pro Tools LE) + blank media. We even give you an Alchemea t-shirt and a subscription to the excellent Sound on Sound Magazine!

*Our facilities are open and fully supervised 24 hours a day!*

## **Appendix F: Full Equipment List for Blueprint Studios – Manchester, UK**

### **Room Dimensions:**

Studio 1 control room:

Dimensions: 7.1m x 4.9m

Surface Area: 34.79 m<sup>2</sup>

Studio 1 (main live room):

Dimensions: 6.8m x 4.9m

Surface Area: 33.32 m<sup>2</sup>

Studio 2 Control Room

Dimensions: 3.9m x 3.2m

Surface Area: 12.48m<sup>2</sup>

Isolation Booth:

Dimensions: 4.9m x 3.5m

Surface Area: 17.15m<sup>2</sup>

The Big Room

Dimensions: 22m x 11m

Surface Area: 242 m<sup>2</sup>

# BLUEPRINT STUDIOS



## studio 1 specifications

Console:	Neve VR Legend 36 Digidesign Command 8
Monitoring:	Genelec 1034B Adam S3A Yamaha NS10 (powered by Bryston 4B)
Pre amps/ channel strips:	Tubetech, Universal Audio, Avalon and SSL
Dynamics:	Universal Audio 1176LN Teletronix LA-2A Empirical Labs Distressor API 2500 Tubetech SMC2B Manley Vari-Mu Alan Smart C2 Manley Massive Passive
FX:	Line 6 Bass Pod Pro Line 6 Guitar Pod Pro TC Electronics Reverb 6000 with ICON remote control Lexicon PCM91
MIDI:	Yamaha Motif Rack Digidesign MIDI
2-track:	Tascam DV-RA1000 Bias Peak Pro
Multi-track:	Digidesign Pro Tools HD3 Accel (over 200 plug ins) Emagic Logic Digidesign 192 (x3) Apple G5 Power Mac

BLUEPRINT STUDIOS  
[www.blueprint-studios.com](http://www.blueprint-studios.com)

Elizabeth House, 39 Queen Street, Manchester, M3 7DQ | T +44 (0) 8700 11 27 60 | F +44 (0) 8700 11 27 80

# BLUEPRINT STUDIOS



## studio 2 specifications

Console:	Digidesign D Command (24 channel)
Monitoring:	Genelec 8050 Yamaha NS10 (powered by Bryston 2B)
Pre amps/ channel strips:	API 3124 x 2 Amek DMCL x 2 Focusrite ISA 430 Avalon VT-737 x 2 Tubetech MEC1A
Dynamics:	Universal Audio 1176LN CLM Expounder Equalizer
FX:	Line 6 Bass Pod Pro Line 6 Pod Pro Lexicon PCM91 Eventide Eclipse
MIDI:	Yamaha Motif Rack ES Tascam Gigastudio sampler Various sample libraries (Vienna Symphonic Library, Holy Grail piano, Bosendorfer, Hammond etc.)
2-track:	Tascam DV-RA1000 Bias Peak Pro Waveburner Pro
Multi-track:	Digidesign Pro Tools HD3 (over 200 plug ins) Emagic Logic Digidesign 192 (x2) Digidesign MIDI Apple G5 Power Mac Pro Tools 24 in 24 out

BLUEPRINT STUDIOS

[www.blueprint-studios.com](http://www.blueprint-studios.com)

Elizabeth House, 39 Queen Street, Manchester, M3 7DQ | T +44 (0) 8700 11 27 60 | F +44 (0) 8700 11 27 80



# BLUEPRINT STUDIOS



## microphones

- Neumann U87 x 2
- Neumann KM184 x 2
- Brauner VM1
- AKG SolidTube
- AKG C414 x 2
- AKG C451 x 2
- AKG D112
- AKG D12
- BLUE KIWI
- Sennheiser MD421 x 3
- Sennheiser E602 x 2
- Sennheiser E604 x 3
- Electrovoice RE20
- Shure SM58 x 3
- Shure SM57 x 5
- Shure Beta58 x 1
- Shure Beta57 x 2
- Audiotechnica ATM87 PZM
- Audiotechnica AT804

BLUEPRINT STUDIOS

[www.blueprint-studios.com](http://www.blueprint-studios.com)

Elizabeth House, 39 Queen Street, Manchester, M3 7DQ | T +44 (0) 8700 11 27 60 | F +44 (0) 8700 11 27 80

## **Appendix G: Equipment List for CB Productions – Jamaica Plain, MA**

### Tracking & Monitoring Systems:

Digidesign ProTools HD w/ Digidesign 192 Interface

Digidesign ProTools LE w/ DIGI 002 Interface

Mackie d8b mixing console

Mackie HR824 monitor speakers

Genelec 1029a monitor speakers

2 Apogee Mini-Me A/D Converters

Avalon Vt 737sp Microphone

Pre-amp/Compressor/EQ

Oram Sonics Octosonic 8-Channel mic pre

Great River Electronics 2-Channel mic pre

### Studio Vocal Microphones:

1 Neumann M149 tube microphone

1 Neumann U87 microphone

3 Neumann TLM 103 condenser microphones

2 AKG 414 EB condenser microphones

2 Audio Technica 4050/CM5 condenser microphones

2 Shure SM81 condenser microphones

1 Shure SM58 microphone

1 Shure SM57 microphone

1 RODE NT1-A microphone

## Post Production Tools:

Waves Gold Bundle

Oxford EQ, Dynamics, and Inflator

Oxford Reverb

Antares Auto-Tune

Antares Filter

Amplitube

Native Instruments Vokator

MOTU MachFive Sampler

Denon DN-S1000 CD DJ Scratch unit

Lexicon PCM 80 Digital Effects Processor

Alesis MidVerb IV Effects Processor

## Live Recording Equipment:

Yamaha 01V mixing board

Tascam DA-88 digital 8-track recorder

Marantz PMD 670 stereo digital recorder

dbx 2231 31-band EQ

Behringer Feedback Destroyer

2 Mackie SR1530 3-way crossover powered speakers

2 JBL EON 15 G2 2-way crossover powered monitor speakers

3 Neumann KMS105 stage condenser microphones

2 Shure SM81 condenser microphones

2 Neumann TLM 103 condenser microphones

2 Shure Wireless SM58s

1 Shure Wireless Lapel Microphone

## Appendix H: WPI Recording Club Special Funding Request Equipment List

1/12/10				
<u>Vendor</u>	<u>Product</u>	<u>Quantity</u>	<u>Raw Cost</u>	<u>Extended Cost</u>
<b>Apple</b>				
	Apple Mac Pro [Educational]	1	\$3,089.00	\$3,089.00
	Kensington ComboSaver Lock	1	\$29.95	\$29.95
	Subtotal			\$3,118.95
	Tax			\$194.93
	Shipping	Free		\$-
	<b>Total</b>			<b>\$3,313.88</b>
<b>Dell</b>				
	S2409W 24-inch Monitor	1	\$279.00	\$279.00
	Subtotal			\$279.00
	Tax			\$17.44
	Shipping	Free		\$-
	<b>Total</b>			<b>\$296.44</b>
<b>Sweetwater</b>				
	Pro Tools LE 8 [Educational]	1	\$75.95	\$75.95
	MP Toolkit 2 [Educational]	1	\$248.00	\$248.00
	PT Advance Line Keyboard	1	\$124.90	\$124.90
	Seagate Barracuda 500 GB	2	\$79.97	\$159.94
	SIIG PCI-e Firewire Card	1	\$79.99	\$79.99
	Galaxy CM-130 dB Meter	1	\$59.99	\$59.99
	Subtotal			\$748.77
	Tax			\$46.80
	Shipping	Free		\$-
	<b>Total</b>			<b>\$795.57</b>
<b>Misc</b>				
	Rat Sniffer/Sender XLR Tester	1	\$42.95	\$42.95
	Cable Lock (For Mac)	1	\$20.00	\$20.00
	Dymo Letra Tag Label Maker	1	\$18.89	\$18.89
	American Apparel T-Shirts (1/2)	15	\$15.10	\$113.25
	Subtotal			\$195.09
	Tax			\$12.19

	Shipping			\$10.00
	<b>Total</b>			\$217.28
<b>Operating</b>				
	Food Meetings (1 per semester)	2	\$75.00	\$150.00
	Printing	1	\$20.00	\$20.00
	Office Supplies	1	\$30.00	\$30.00
	Subtotal			\$200.00
	<b>Total</b>			\$200.00
			<b>Total</b>	<b>\$4,823.17</b>

# Appendix I: My Proposal for Individually-Designed Major in Audio Engineering and Production

Approved 10/29/2008

*Audio Engineering and Production* is the study of the nature, capture, and manipulation of audio. This includes several aspects of audio, including acoustics, sound recording technologies, the mixing and editing of audio, music production, the electronics entailed in manipulating audio signals (including microphone transducers, amplifiers, speakers, filters, etc).

There are several schools with similar programs:

- Berklee College of Music – Music Production and Engineering  
<http://www.berklee.edu/majors/mpe.html>
- University of Hartford Hartt School – Music Production and Technology  
<http://harttweb.hartford.edu/adm-programs-music.asp?id=19>
- University of Massachusetts Lowell – Sound Recording Technology  
[http://www.uml.edu/College/arts\\_sciences/Music/Programs\\_of\\_Study/Undergraduate\\_Music\\_Programs/Sound\\_Recording\\_Technology\\_Program/srt.html](http://www.uml.edu/College/arts_sciences/Music/Programs_of_Study/Undergraduate_Music_Programs/Sound_Recording_Technology_Program/srt.html)

## Objectives

The program will offer training in electrical engineering, physics, music, and management, as well as hands-on training in a recording studio environment. The educational objectives of this audio engineering and production program are to prepare students to act as audio design engineers, acousticians, recording/mixing engineers, and music producers. Though students can concentrate in one of these areas, the concept here is to prepare students for a multi-faceted audio career.

## Program distribution requirements for the major:

1. Mathematics	2 units
2. Physics	1 unit
3. Electrical and Computer Engineering	2 units
4. Music	1 unit
6. Audio Engineering and Production*	4 units

## **\*Audio Engineering and Production**

Four units of Audio Engineering and Production is inclusive of nine Independent study courses (1/3 unit each), and the Major Qualifying Project (1 unit) at the core of the major. These courses consist of the following:

Introduction to Pro Tools – John Delorey

Recording Capture Techniques – John Delorey

Mixing Techniques – John Delorey

Effects and Post-Production Techniques – John Delorey

Applied Acoustics – Richard Campbell

Ear Training for the Audio Engineer – John Delorey, Richard Falco

The Recording Industry – John Delorey

Horn Design, Audio Circuit Design Project – Richard Campbell, William Michalson

MIDI Systems for Music Production – Frederick Bianchi

## **Faculty Advisors**

My three advisors for this program are John Delorey (HUA/Music Division), Richard Falco (HUA/Music Division), and William Michalson (ECE Dept.). All three have consented to be a part this program.

## **MQP**

For the final project (MQP), I would like to evaluate the studio setup at WPI. This would include making new plans, including designs for an isolation booth, in order to expand the current setup into a fully-functional recording studio. My advisor will be Professor John Delorey, whose experience in this field is substantial.

## **Future Goals**

Upon earning my degree, I plan to work for a sound design/professional audio company to gain experience with electronics applications in audio. I would like to continue with graduate school, where I would further my studies not only in engineering, but in applied music. I plan to work at a commercial recording studio where I can expand my knowledge and increase awareness of successful business practices. My long-term goal is to own a recording studio where I would function as chief engineer and in-house creative talent. An audio engineering and production degree as described above would provide me with the many tools needed for several career opportunities.