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A13.5

Baseline Vibration Monitoring at Trinity College Dublin

Report for:

Jacobs Engineering Ireland Ltd

Metrolink

Baseline Vibration Monitoring at Trinity College, Dublin

Status: Final **Date: 19.12.2019**

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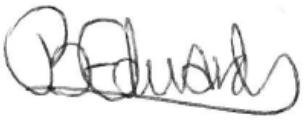
Contributors	 Rebecca Edwards BSc (Hons) MSc MIOA Senior Acoustic Consultant
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1. INTRODUCTION

ACCON UK (ACCON) have been commissioned by Jacobs Engineering Ireland Ltd (Jacobs) to carry out baseline vibration monitoring at sensitive locations within Trinity College Dublin to inform the assessment of vibration for the proposed Metrolink railway line through Dublin City Centre. The vibration measurements commenced on Tuesday 19th November and were completed on Thursday 21st November. Where possible, noise measurements were also taken simultaneously in order to determine sound pressure levels with C weighting.

The purpose of the baseline vibration monitoring is to ascertain the current existing levels of vibration at locations where sensitive equipment is located, including scanning electron microscopes (SEM), nuclear magnetic resonance (NMR) equipment and similar units which have operating requirements specified both in terms of vibration and noise. In many cases the equipment is installed on a suspension system or has active isolation.

The Jacobs Engineering 'Survey Scope' dated 07/05/2019 provides the following example specification for the room conditions of a SEM:

- "*Vibration: to obtain the specified performance, the room's floor vibration must not exceed the following specification:*
    - *pneumatic suspension (LM, XM): < 5 µm/s 0-30 Hz; < 10 µm/s above 30 Hz;*
    - *active isolation (option for LM, XM): < 10 µm/s 0-30 Hz; < 20 µm/s above 30 Hz.*
- *Acoustic vibration: to obtain specified microscope performance the acoustic vibration in the room while the microscope is in operation must not exceed: 60 dB(C).*"

It is considered that 'acoustic vibration' refers to the total airborne noise level (comprised of ambient noise and groundborne noise from vibrations) within the room of operation of the SEM.

An estimation of NMR sensitivity to horizontal vibration (the most sensitive axis) provided within the Jacobs Engineering 'Survey Scope' dated 07/05/2019 is "*approximately 10 µm/s^2 at 4 Hz and 1000 µm/s^2 at 60 Hz which in velocity terms is a minimum of 0.4 µm/s*".

The results of baseline vibration monitoring will be utilised to inform the baseline for the purposes of the Environmental Impact Assessment of the MetroLink project.

Demolition works at the former Biochemistry Building were taking place during the measurement survey. This building is located in between the Lloyd Institute and the Panoz Building and some of the measurements were carried out in each of these buildings. The effect of these demolition works has been detailed in this report. At some locations the measurements detected train movements from the Dublin Area Rapid Transit (DART) Line running into Pearse Station. The train movements would form part of the existing baseline.

This report provides a summary of the noise and vibration monitoring equipment, the monitoring locations, baseline monitoring results and the sources of noise and vibration which were observed at each location.

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2. MONITORING METHODOLOGY AND EQUIPMENT

2.1. Baseline Vibration Measurement Methodology

The Survey Scope indicated that baseline vibration monitoring was required in at least two locations for each sensitive equipment installation:

- One immediately beside the base of the unit; and
- One at least 1 m away.

In addition to the basic requirements, subject to the availability of space around each item, additional vibration measurements were taken e.g. 2 m from each item. The Survey Scope requires a duration of measurement long enough to cover at least one or two cycles of operation if a cycling characteristic occurs, otherwise the duration should be long enough to acquire a stable uncontaminated recording (e.g. 1 minute).

The locations were all tailored to the specific sensitive equipment installations and room layouts, as described for each monitoring location in **Section 3** of this report. Similarly, the local circumstances at each location dictated the measurement durations, which have also been detailed in **Section 3.**

Two sets of vibration monitoring equipment were utilised during the measurement survey. Each set consisted of three single axis high sensitivity (10 V/G) accelerometers magnetically mounted to a plastic block glued to a heavy metal plate. Due to the use of these metal plates, vibration measurements in close proximity to equipment with strong magnetic fields were not possible. A calibration signal was applied to each of the accelerometers prior to the commencement of each set of measurements to ensure that the baseline measurements could be accurately calibrated during analysis.

2.2. Baseline Airborne Noise Monitoring Methodology

The proposed methodology aimed to carry out airborne noise monitoring simultaneously with the vibration monitoring at the following locations for each sensitive equipment installation:

- Noise measurements 1 m from each significant exposed survey of the unit; and
- One between 2 m and 5 m from the unit, if there is sufficient space around the unit.

As for vibration, the locations were all tailored to the specific equipment installations and room layouts, as described for each monitoring location in **Section 3** of this report

Sound level meters were set up on tripods with the microphone at a height of 1.5m. Where possible sound level meters were not placed near reflective surfaces, apart from the floor. The Sound Level Meters were field calibrated before and after each measurement period to ensure that each instrument had remained within reasonable calibration limits (±0.5 dB).

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2.3. Monitoring Equipment

Table 3.1 identifies the vibration and noise measurement equipment that was utilised during the monitoring. All of the items of equipment have current certificates of calibration which can be made available upon request.

Table 2.1: Equipment List

Equipment	Make	Model	Serial No
Accelerometers	LANCE	LC0116A	1- h981
			2- h984
			3- h993
			4- 0103
			5- h104
			6- h109
Data Recorder	Rion	DA-20	34521705
Data Recorder	Rion	DA-21	00150215
Vibration Calibrator	Bruel and Kjær	4294	1884114
Sound Level Meters	Svantek	971	34396
			60027
Sound Level Calibrator	Norsonic	1251	17418

2.4. Monitoring Results

Section 3 of this report presents a summary of the noise and vibration baseline monitoring results for each sensitive equipment item.

Due to the large volume of monitoring data obtained, the full monitoring results have been issued separately in electronic format including, vibration acceleration and velocity values in one-third octave bands over the frequency range 0.4 Hz – 400 Hz. The A-weighted and C-weighted peak and L_{eq} noise levels have also been provided.

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3. NOISE AND VIBRATION MONITORING RESULTS

The noise and vibration monitoring survey included 10 locations within various buildings and floors of the scientific buildings at Trinity College Dublin. Noise and Vibration measurements were carried out where equipment and instruments that are considered sensitive to external sources of vibration are located. A schedule of monitoring locations was provided to ACCON by Jacobs based on information provided by Trinity College Dublin prior to the site visit. The exact monitoring locations were determined during the monitoring exercise based on the practicalities of each equipment installation. This process was carried out by ACCON personnel in conjunction with representatives of Trinity College Dublin.

The vibration measurements determined the acceleration level in one-third octave frequency bands at each location which has then been utilised to determine the velocity level in one-third octave frequency bands at each location.

The summarised results of the noise measurements have identified the A-weighted and C-weighted noise levels. This made it possible to identify locations that have a large proportion of low frequency noise by comparing the two different weightings. Where the C-weighted level is significantly higher than the A-weighted value, this indicates the presence of higher levels of low frequency sound.

This report provides a summary of the baseline noise and vibration measurements at each of the measurement positions. Various indices have been identified in the summary results for each measurement position. Detailed noise and vibration data including the one-third octave band data will be made available in a separate document.

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3.1. CRANN Building, Room -2.32, Scanning Tunnelling Microscope

This room is located in the lower basement of the CRANN building, two floors below ground level. The sensitive equipment in the room included two Scanning Tunnelling Microscopes (STMs) on vibration isolation mounts that were placed on bespoke inertia blocks to provide vibration isolation from the building. The floor of the room itself was also isolated from the adjoining corridor. Due to the position being located in the basement, the exact location of the room in relation to the DART Line is not known.

Two vibration measurement positions and one noise measurement position were utilised within this room:

- Vibration Measurement Position One (VMP1) was located on the inertia block, adjacent to one of the STMs;
- Vibration Measurement Position Two (VMP2) was located 1.7m from VMP1 on the tiled floor of the room;
- Noise Measurement Position One (NMP1) was located centrally between the two STMs, approximately 60cm horizontally from VMP1 on a tripod at a height of 1.5m.

The STMs were not operational during the noise and vibration measurements. There was an air conditioning unit operational in the room which dominated the noise within the room as well as some noise from racks containing support equipment. Trains running on the DART line to and from Pearse Station were audible within the room and could be seen to affect the vibration levels in the room. It is unlikely that the demolition of the Biochemistry Building had a noticeable effect on the vibration levels in the room.

Figure 3.1 identifies the positions of the sensitive equipment and measurement positions within the room as well as the directions of the X and Y axis for the vibration measurements, with Z being vertical. **Figure 3.2** identifies the approximate location of the measurements in relation to the DART line.

Figure 3.1: Measurement positions within Room-2.32 of the CRANN Building

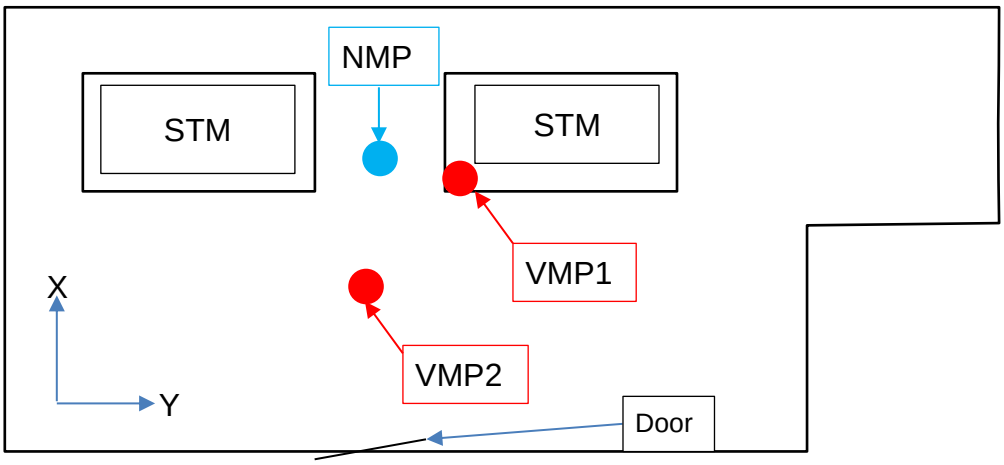

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Figure 3.2: Measurement Location within the CRANN Building

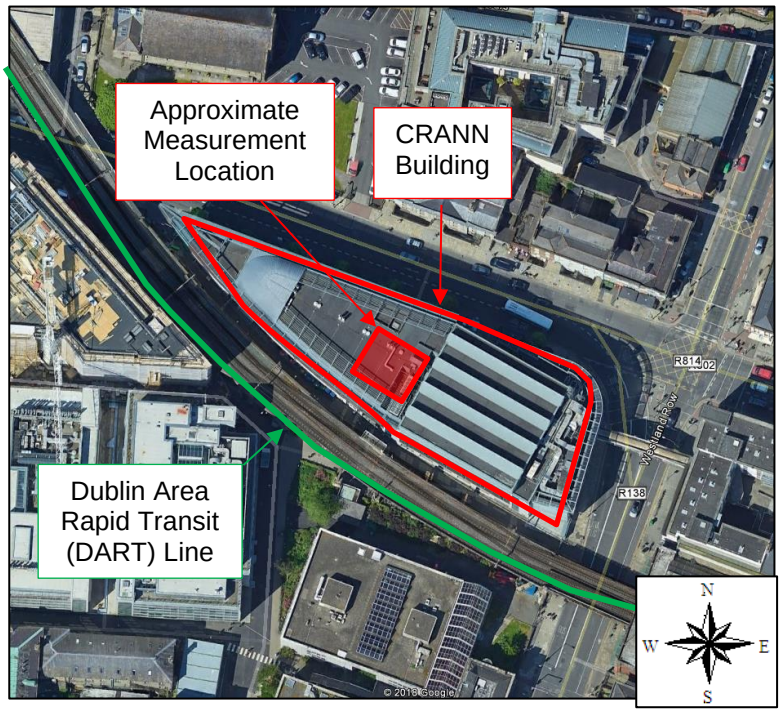

Table 3.1 identifies the baseline vibration measured at VMP1. **Table 3.2** identifies the baseline vibration measured at VMP2. **Table 3.3** identifies the results of the noise monitoring at NMP1. The baseline is based on a 10 minute period of the measurements in which the main source of vibration was from trains on the DART line.

Table 3.1: Summary of Vibration Results for VMP1

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0020	0.0018	0.0009	0.0114	0.0114	0.0054
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0020	0.0019	0.0021	0.0119	0.0117	0.0123
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0140	0.0126	0.0064	0.0804	0.0757	0.0345
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0140	0.0125	0.0093	0.0813	0.0763	0.0545

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Table 3.2: Summary of Vibration Results for VMP2

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0054	0.0016	0.0007	0.0100	0.0038	0.0041
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0078	0.0034	0.0041	0.0164	0.0079	0.0132
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0429	0.0150	0.0090	0.0829	0.0363	0.0319
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0441	0.0154	0.0115	0.0856	0.0367	0.0417

Table 3.3: Summary of Noise Results for NMP1

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
54	74	60	76

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3.2. CRANN Building, Room 2.33, Scanning Tunnelling Microscope

This room is located on the second floor of the CRANN building. The sensitive equipment in the room included two Scanning Tunnelling Microscopes (STMs).

Two vibration measurement positions and one noise measurement position were utilised within the room:

- Vibration Measurement Position Three (VMP3) was located on the floor adjacent to a STM near the centre of the room;
- Vibration Measurement Position Four (VMP4) was located on the floor approximately 5m to the south of VMP3;
- Noise Measurement Position Two (NMP2) was located 2 m to the north of VMP4 on a tripod at a height of 1.5m.

The STMs were not operational during the measurements however there was intermittent activity from students working on projects within the room and some of the support equipment was operational. Support equipment typically comprised compressors for the vacuum systems utilised with the STMs, pumps and a gas supply valve which rattled. There was also an air conditioning unit operational in the room. Trains running on the DART line to and from Pearse Station were audible and also affected the vibration levels in the room at VMP4. It is unlikely that the demolition of the Biochemistry Building had a noticeable effect on the vibration levels in the room.

Figure 3.3 identifies the positions of the sensitive equipment and measurement positions within the room as well as the directions of the X and Y axis for the vibration measurements, with Z being vertical. The Y direction was approximately parallel to the railway line with the X axis being perpendicular. **Figure 3.4** identifies the approximate location of the measurements in relation to the DART line.

Figure 3.3: Measurement Positions within Room 2.33 of the CRANN building

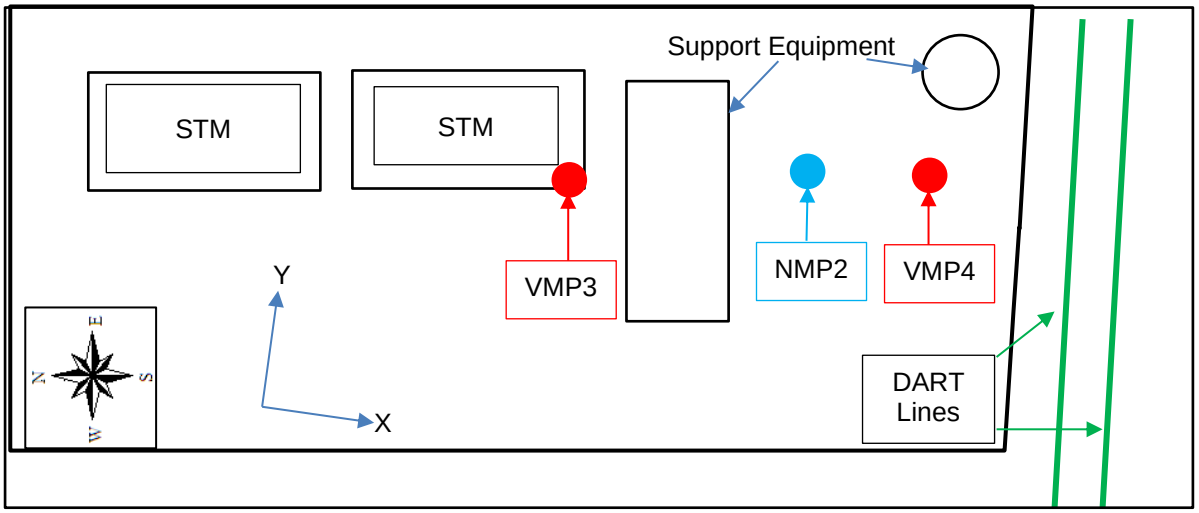

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Figure 3.4: Measurement Location within the CRANN Building

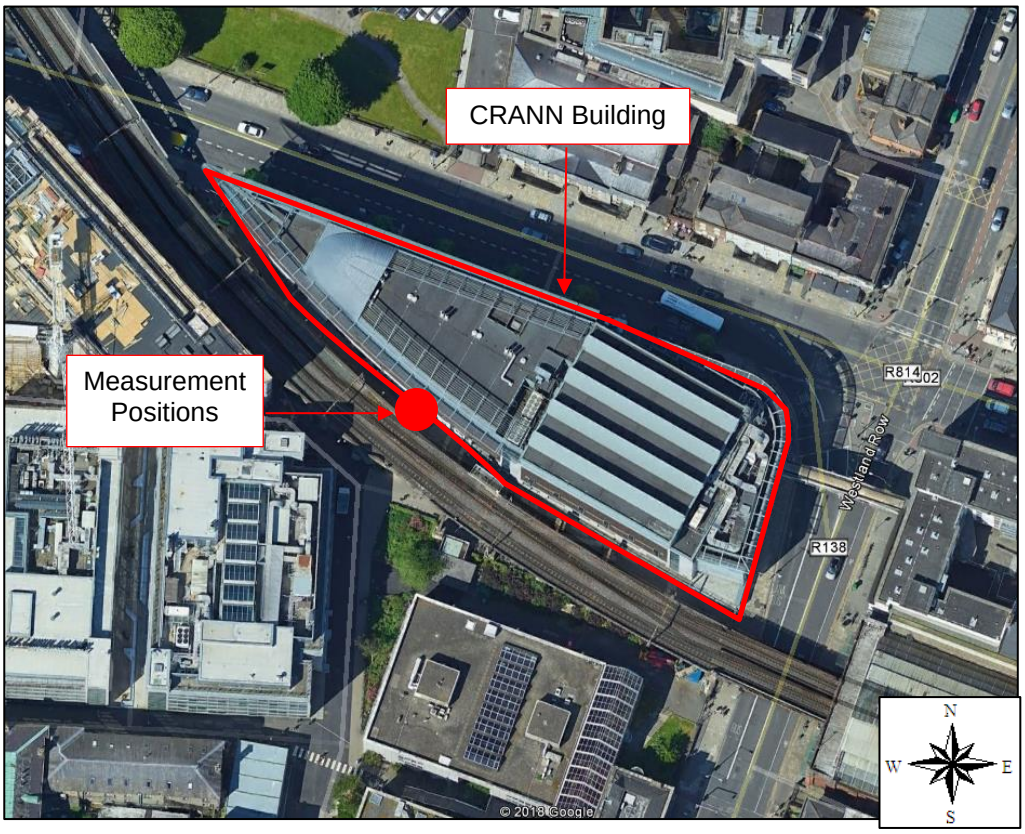

Table 3.4 identifies the baseline vibration measured at VMP3. **Table 3.5** identifies the baseline vibration measured at VMP4. **Table 3.6** identifies the results of the noise monitoring at NMP2. The baseline is based on a 17 minute period of the measurements where the main source of vibration was from trains on the DART line.

Table 3.4: Summary of Vibration Results for VMP3

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0009	0.0007	0.0036	0.0071	0.0044	0.0134
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0010	0.0014	0.0046	0.0075	0.0052	0.0174
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0082	0.0066	0.0263	0.0592	0.0382	0.1015
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0079	0.0064	0.0253	0.0593	0.0380	0.1032

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Table 3.5: Summary of Vibration Results for VMP4

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0009	0.0008	0.0025	0.0074	0.0060	0.0099
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0019	0.0017	0.0037	0.0094	0.0078	0.0126
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0082	0.0070	0.0147	0.0603	0.0464	0.0660
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0087	0.0074	0.0166	0.0619	0.0476	0.0704

Table 3.6: Summary of Noise Results for NMP2

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
58	86	65	86

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3.3. Chemistry Building, Nuclear Magnetic Resonance

Two rooms located in the basement of the Chemistry Building contain three Nuclear Magnetic Resonance instruments (NMRs). The NMRs were operational at the time of the measurements and due to the presence of high strength magnetic fields generated by the NMRs, it was not possible to measure in close proximity to the equipment without risk of damage to the NMRs or the vibration measurement equipment. The measurement positions were located such that there was not a risk of damage to any of the equipment and a suitable baseline could be measured.

The rooms were isolated from the adjoining corridor. Room One was slightly elevated in comparison to Room Two. Due to the position being located in the basement, the exact positioning in relation to the demolition works is not known and therefore demolition activities may have had an effect on the measured vibration levels. However, the demolition was not noted to be of concern for the operators of the NMRs.

There were air compressors operational in the connecting room adjacent to the first set of measurements which dominated the noise climate within the room. Students and staff occasionally entered and left the rooms under test but generally kept activities to a minimum.

Three vibration measurement positions and one noise measurement position were utilised within these rooms:

- Vibration Measurement Position Five (VMP5) was located on the floor of Room One approximately 3m from the NMR in this room. It was noted that measurement position VMP5 was located approximately half way between the NMR in Room One and one of the NMRs in Room Two;
- Vibration Measurement Position Six (VMP6) was located on the floor of Room One approximately 4m from VMP5;
- Vibration Measurement Position Seven (VMP7) was located on the floor of Room Two approximately 4m from the NMRs, just inside the door as to not be at risk from or to the two NMRs;
- Noise Measurement Position Three (NMP3) was located approximately 3m from the NMR in Room Two on a tripod at a height of 1.5m.

Figure 3.5 identifies the positions of the sensitive equipment and measurement positions within the room as well as the directions of the X and Y axis for the vibration measurements, with Z being vertical. **Figure 3.6** identifies the approximate location of the measurements in the building in relation to the demolition works.

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Figure 3.5: Measurement Locations within NMR rooms in the Chemistry Building

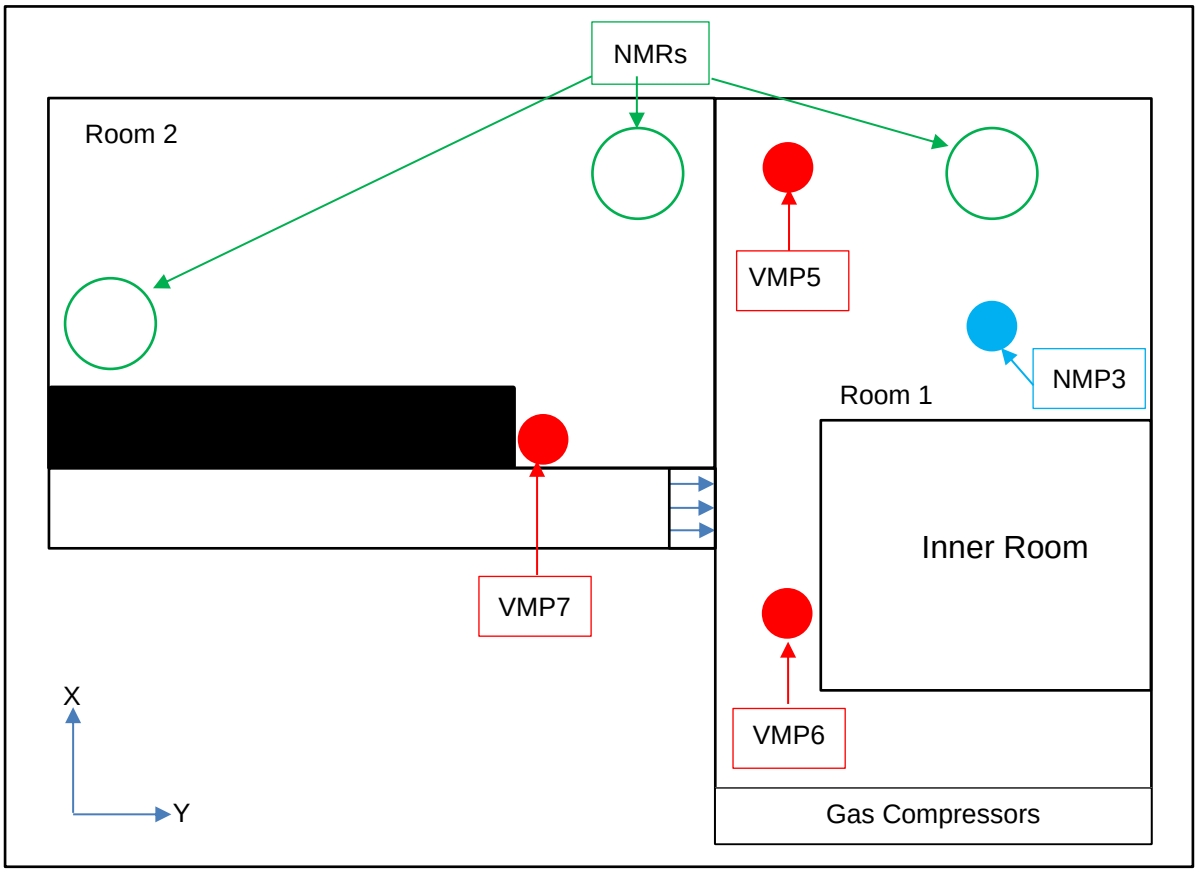

Figure 3.6: Measurement Location within the Chemistry Building

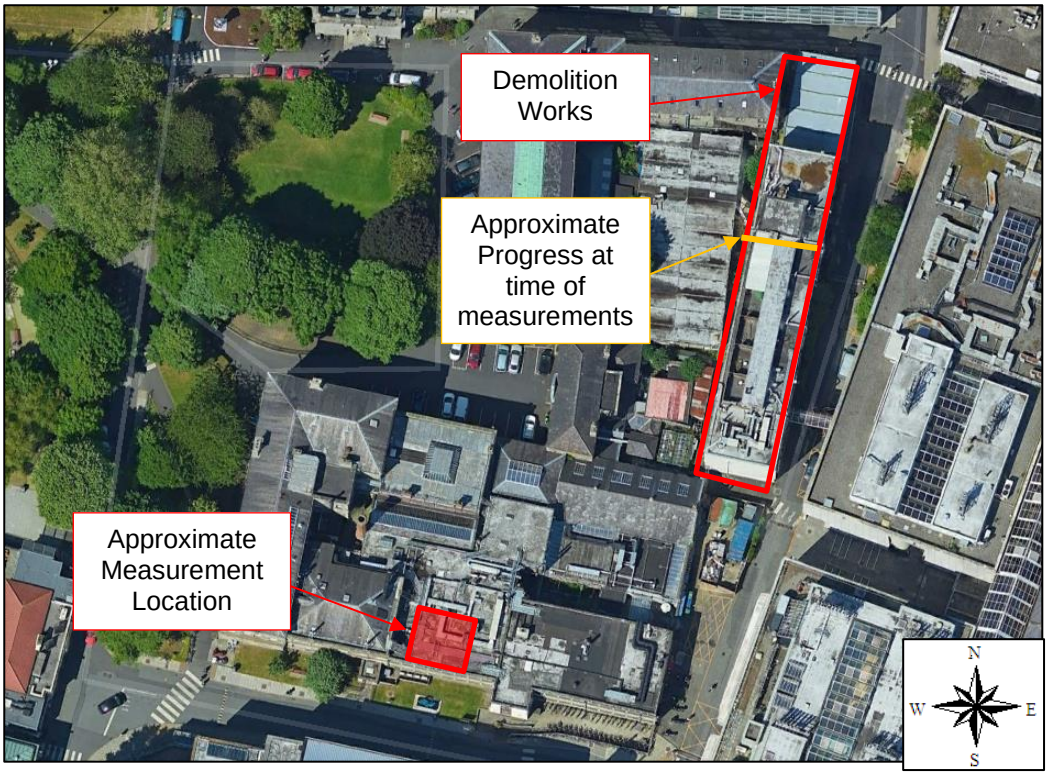

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Table 3.7 identifies the baseline vibration measured at VMP5. **Table 3.8** identifies the baseline vibration measured at VMP6. **Table 3.9** identifies the baseline vibration measured at VMP7. **Table 3.10** identifies the baseline vibration measured at NMP3. The vibration baseline is based on a 35 minute period of the measurements. The noise baseline is based on a relatively quiet 13 minute period which excludes noise from staff and students in the room.

Table 3.7: Summary of Vibration Results for VMP5

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0001	0.0001	0.0002	0.0005	0.0004	0.0009
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0001	0.0002	0.0005	0.0012	0.0010	0.0027
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0018	0.0026	0.0028	0.0068	0.0079	0.0098
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0012	0.0016	0.0023	0.0055	0.0053	0.0089

Table 3.8: Summary of Vibration Results for VMP6

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0001	0.0001	0.0002	0.0007	0.0005	0.0008
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0007	0.0005	0.0010	0.0034	0.0022	0.0067
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0030	0.0025	0.0027	0.0151	0.0091	0.0115
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0021	0.0017	0.0028	0.0108	0.0068	0.0151

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Table 3.9: Summary of Vibration Results for VMP7

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0002	0.0001	0.0003	0.0006	0.0004	0.0014
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0002	0.0003	0.0006	0.0010	0.0009	0.0022
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0027	0.0028	0.0032	0.0089	0.0079	0.0107
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0020	0.0020	0.0029	0.0081	0.0059	0.0106

Table 3.10: Summary of Noise Results for NMP3

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
57	79	64	79

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3.4. Monck Observatory

The Monck Observatory is located on the roof of the Fitzgerald Building. The sensitive equipment on the roof included a solar/optical telescope and a radio telescope. The optical telescope is located within a dome which is mounted on raised girders that are fixed into the walls of the Fitzgerald Building. The optical telescope itself is mounted on a solid concrete base. The radio telescope is mounted directly onto the roof of the Fitzgerald Building. Neither telescope was operational during the measurements.

No noise measurements were carried out on the roof as any reradiated noise from vibration would not be significant compared to the ambient noise climate. Two vibration measurement positions were utilised on the roof:

- Vibration Measurement Position Eight (VMP8) was located on the optical telescope dome base;
- Vibration Measurement Position Nine (VMP9) was located adjacent to the radio telescope base.

Figure 3.7 identifies the location of the measurements in relation to the demolition works. **Figure 3.8** identifies the positions of the sensitive equipment and measurement positions on the roof as well as the directions of the X and Y axis for the vibration measurements, with Z being vertical. It is unlikely that the demolition of the Biochemistry Building had a noticeable effect on the vibration levels on the roof of the Fitzgerald Building.

Figure 3.7: Measurement Location at the Monck Observatory

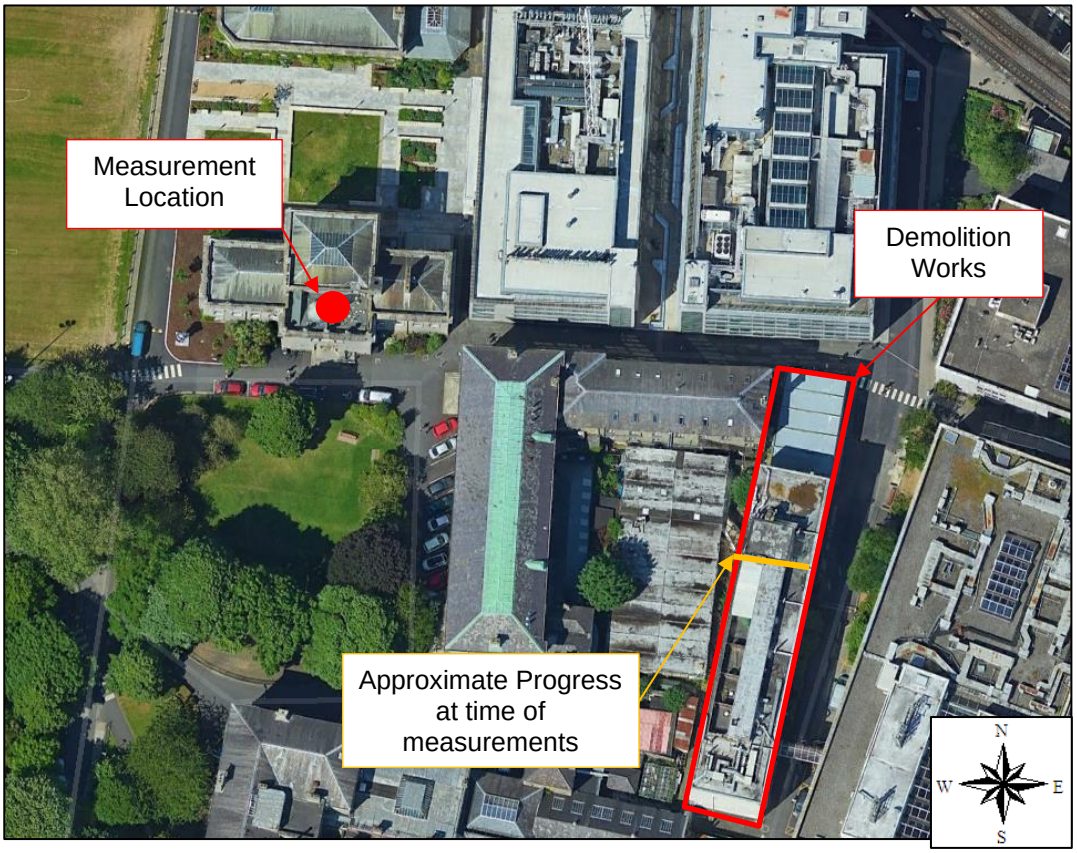

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Figure 3.8: Measurement Positions on the Monck Observatory

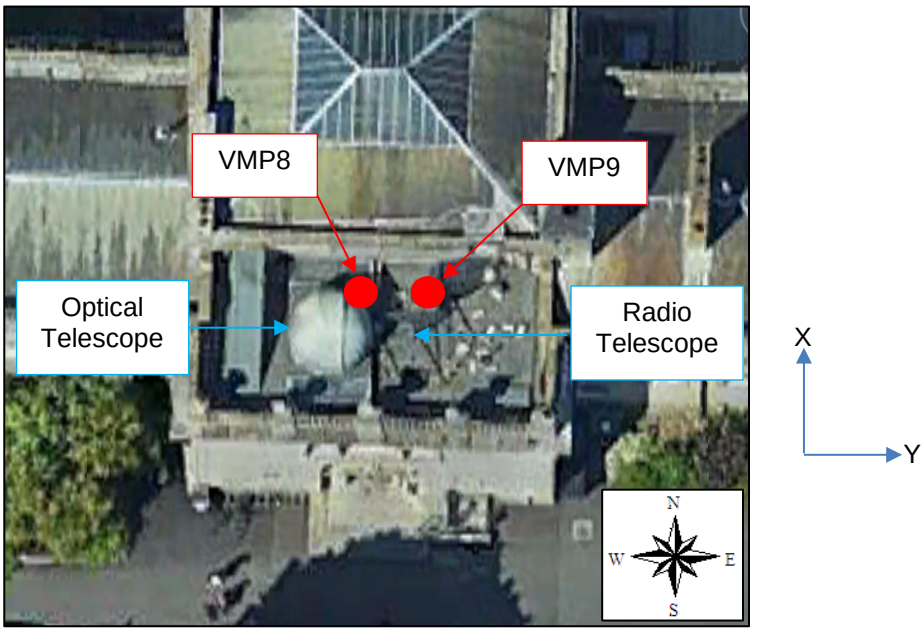

Table 3.11 identifies the baseline vibration measured at VMP8. **Table 3.12** identifies the baseline vibration measured at VMP9. The vibration baseline at these positions is based on a 22 minute period of the measurements.

Table 3.11: Summary of Vibration Results for VMP8

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0009	0.0007	0.0015	0.0033	0.0024	0.0048
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0016	0.0021	0.0041	0.0066	0.0114	0.0361
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0131	0.0132	0.0170	0.0470	0.0492	0.0609
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0133	0.0134	0.0169	0.0480	0.0505	0.0810

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Table 3.12: Summary of Vibration Results for VMP9

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0004	0.0003	0.0130	0.0026	0.0014	0.0550
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0013	0.0010	0.0150	0.0058	0.0066	0.0686
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0072	0.0043	0.1214	0.0443	0.0289	0.6536
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0071	0.0043	0.1220	0.0384	0.0315	0.6572

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3.5. Fitzgerald Building, Room 0.1, Scanning Tunnelling Microscope

This room is located on the ground floor of the Fitzgerald Building. The sensitive equipment in the room included a Scanning Tunnelling Microscope (STM). The STM was not operational during the measurements.

There were support equipment in racks in the room which emitted a low level of noise within the room. Cars and vans on the roads directly outside of the room were audible and also affected the vibration levels in the room. People closing doors and the lift with the building affected the measurements and would be considered part of the existing baseline. It is unlikely that the demolition of the Biochemistry Building had a significant effect on the vibration levels in the room.

Three vibration measurement positions and two noise measurement position were utilised within the room:

- Vibration Measurement Position Ten (VMP10) was located directly adjacent to the STM;
- Vibration Measurement Position Eleven (VMP11) was located 1m to the south of VMP10;
- Vibration Measurement Position Twelve (VMP12) was located 1m to the south of VMP11;
- Noise Measurement Position Four (NMP4) was located adjacent to the STM on a tripod at a height of 1.5m above VMP10;
- Noise Measurement Position Five (NMP5) was located in the south-western corner of the room on a tripod at a height of 1.5m.

Figure 3.9 identifies the location of the measurements in relation to the demolition works. **Figure 3.10** identifies the positions of the sensitive equipment and measurement positions within the room as well as the directions of the X and Y axis for the vibration measurements, with Z being vertical.

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Figure 3.9: Measurement Location within the Fitzgerald Building

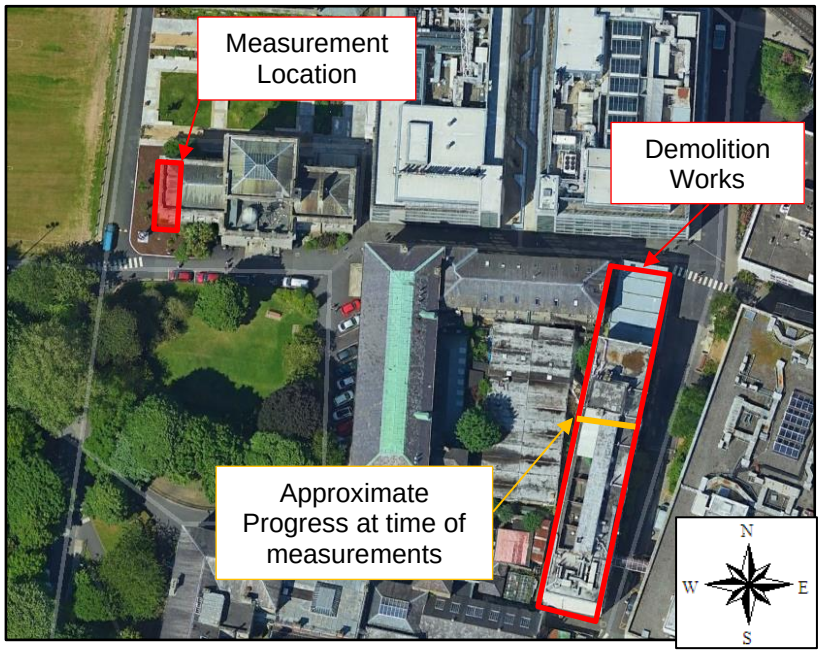

Figure 3.10: Measurement Positions within Room 0.1 of the Fitzgerald Building

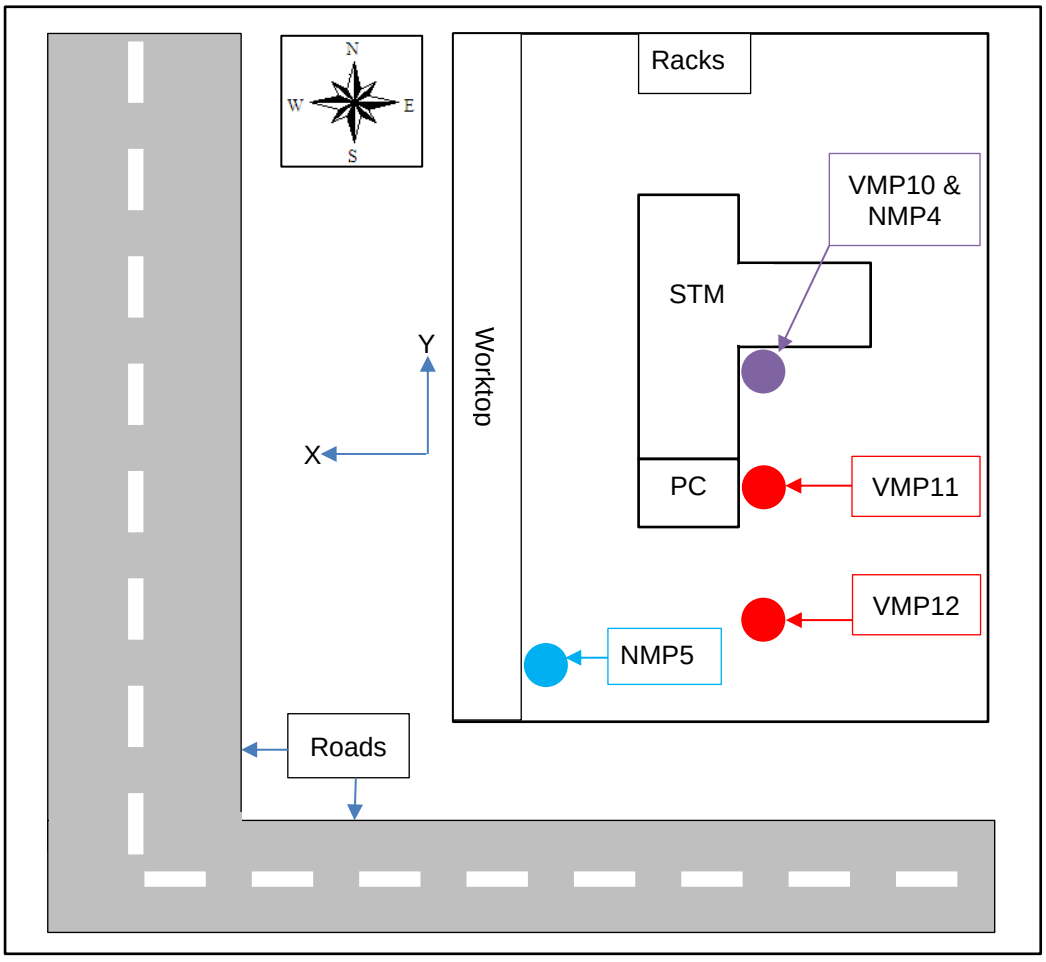

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Table 3.13 identifies the results of the vibration monitoring at VMP10. **Table 3.14** identifies the results of the vibration monitoring at VMP11. **Table 3.15** identifies the results of the vibration monitoring at VMP12. **Table 3.16** identifies the results of the noise monitoring at NMP4. **Table 3.17** identifies the results of the noise monitoring at NMP5. The baseline is based on a 30 minute period of the measurements.

Table 3.13: Summary of Vibration Results for VMP10

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0002	0.0002	0.0005	0.0015	0.0015	0.0044
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0002	0.0003	0.0005	0.0016	0.0018	0.0045
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0027	0.0025	0.0035	0.0155	0.0147	0.0323
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0019	0.0024	0.0035	0.0145	0.0147	0.0323

Table 3.14: Summary of Vibration Results for VMP11

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0002	0.0002	0.0004	0.0012	0.0014	0.0020
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0002	0.0003	0.0005	0.0014	0.0017	0.0023
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0021	0.0031	0.0036	0.0126	0.0143	0.0163
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0020	0.0024	0.0031	0.0126	0.0134	0.0154

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Table 3.15: Summary of Vibration Results for VMP12

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0002	0.0003	0.0003	0.0015	0.0029	0.0018
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0003	0.0003	0.0005	0.0016	0.0026	0.0022
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0029	0.0526	0.0031	0.0135	0.5400	0.0142
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0021	0.0150	0.0026	0.0128	0.2060	0.0137

Table 3.16: Summary of Noise Results for NMP4

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
41	72	52	72

Table 3.17: Summary of Noise Results for NMP5

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
41	73	56	77

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3.6. Fitzgerald Building, Room 1.5, Alternating Gradient Field Magnometer

This room is located on the first floor of the Fitzgerald Building. The sensitive equipment in the room included an Alternating Gradient Field Magnometer (AGFM). The AGFM was not operational during the measurement period.

An unidentified plant unit was operational and audible within the room which dominated the noise within the room. Significant noise from a leaf collector outside of the room occurred for a period of approximately ten minutes. It is possible but unlikely that the demolition of the Biochemistry Building had a significant effect on the vibration levels in the room.

Two vibration measurement positions and one noise measurement position were utilised within the room:

- Vibration Measurement Position Thirteen (VMP13) was located adjacent to the AGFM;
- Vibration Measurement Position Fourteen (VMP14) was located one metre to the south of VMP13;
- Noise Measurement Position Six (NMP6) was located adjacent to the AGFM on a tripod at a height of 1.5m above VMP13.

Figure 3.11 identifies the location of the measurements in relation to the demolition works. **Figure 3.12** identifies the positions of the sensitive equipment and measurement positions within the room as well as the directions of the X and Y axis for the vibration measurements, with Z being vertical.

Figure 3.11: Measurement Location with Room 1.5 of the Fitzgerald Building

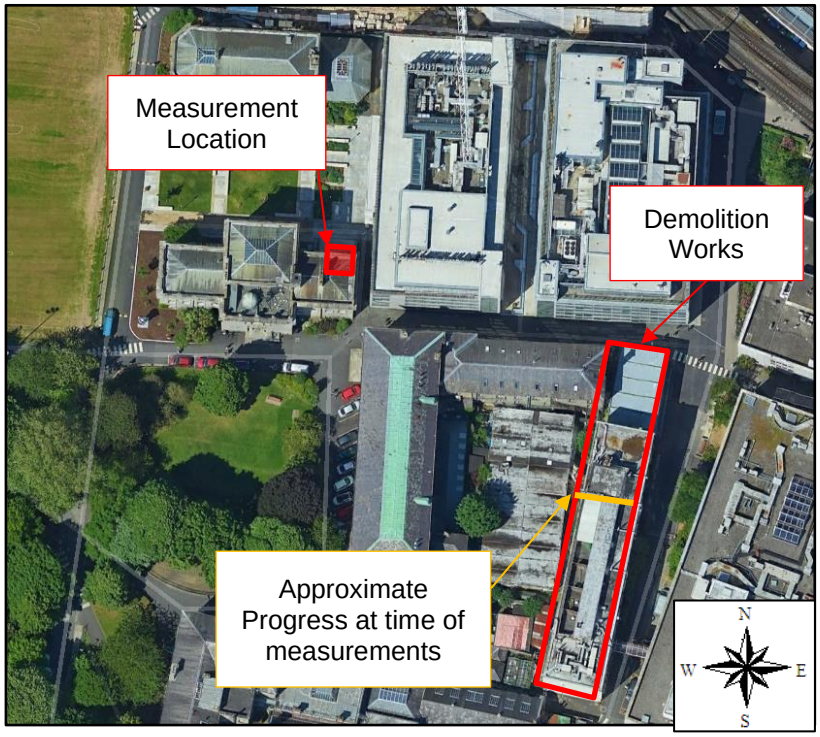

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Figure 3.12: Measurement Positions within Room 1.5 of the Fitzgerald Building

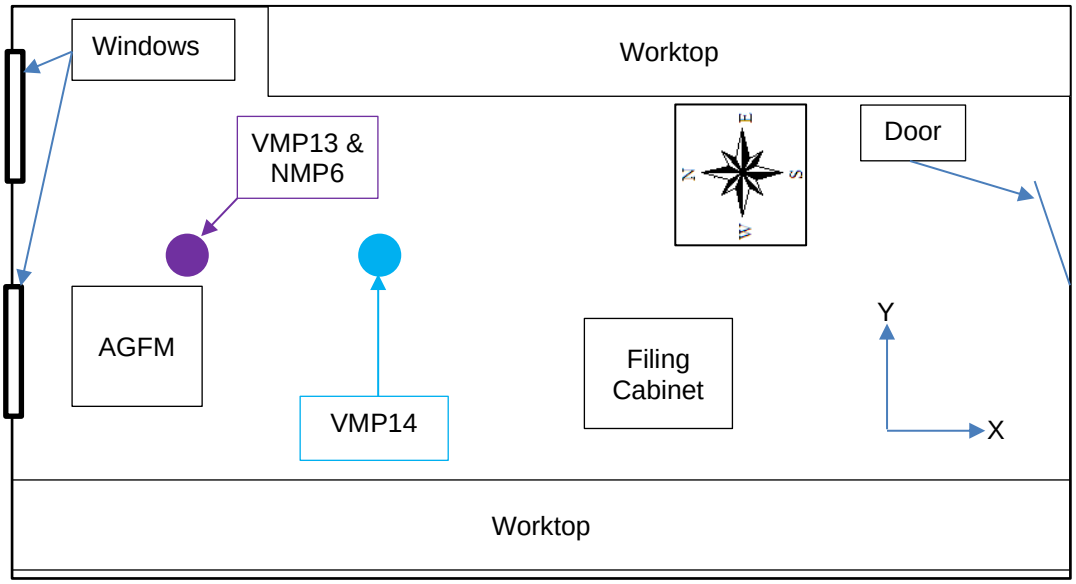

Table 3.18 identifies the results of the vibration monitoring at VMP13. **Table 3.19** identifies the results of the vibration monitoring at VMP14. The vibration baseline is based on a 30 minute period of the measurements. **Table 3.20** identifies the results of the vibration monitoring at NMP6. The noise baseline is based on a 25 minute period excluding the leaf collector as this was an atypical external source that would not form part of the normal baseline.

Table 3.18: Summary of Vibration Results for VMP13

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0011	0.0012	0.0018	0.0023	0.0026	0.0044
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0020	0.0071	0.0038	0.0092	0.0131	0.0111
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0081	0.0087	0.0121	0.0252	0.0263	0.0319
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0083	0.0140	0.0135	0.0254	0.0307	0.0375

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Table 3.19: Summary of Vibration Results for VMP14

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0012	0.0015	0.0031	0.0026	0.0029	0.0064
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0027	0.0045	0.0080	0.0136	0.0156	0.0176
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0085	0.0104	0.0206	0.0219	0.0250	0.0463
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0099	0.0128	0.0236	0.0360	0.0404	0.0538

Table 3.20: Summary of Noise Results for NMP6

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
34	58	61	73

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3.7. SNIAM Building, Room 0.16, SQUID

This room is located on the ground floor of the SNIAM Building. The sensitive equipment in the room included a **S**emiconducting **Qu**antum **I**nterference **D**evice (SQUID). The SQUID was operational during the measurements.

There was a helium compressor unit operational that was the most clearly identifiable noise source in the room. It is unlikely that the demolition of the Biochemistry Building had a noticeable effect on the vibration levels in this room. The vibration levels may have been affected by trains on the DART line.

Three vibration measurement positions and two noise measurement positions were utilised within the room:

- Vibration Measurement Position Fifteen (VMP15) was located adjacent to the SQUID
- Vibration Measurement Position Sixteen (VMP16) was located 2m to the south of VMP15
- Vibration Measurement Position Seventeen (VMP17) was located 2m to the south of VMP16
- Noise Measurement Position Seven (NMP7) was located adjacent to VMP15 on a tripod at a height of 1.5m.
- Noise Measurement Position Eight (NMP8) was located approximately 1m from the helium compressor on a tripod at a height of 1.5m.

Figure 3.13 identifies the approximate location of the measurements in relation to the DART Line and the Demolition Works. **Figure 3.14** identifies the positions of the sensitive equipment and measurement positions within the room as well as the directions of the X and Y axis for the vibration measurements, with Z being vertical.

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Figure 3.13: Measurement Locations within Room 0.16 of the SNIAM Building

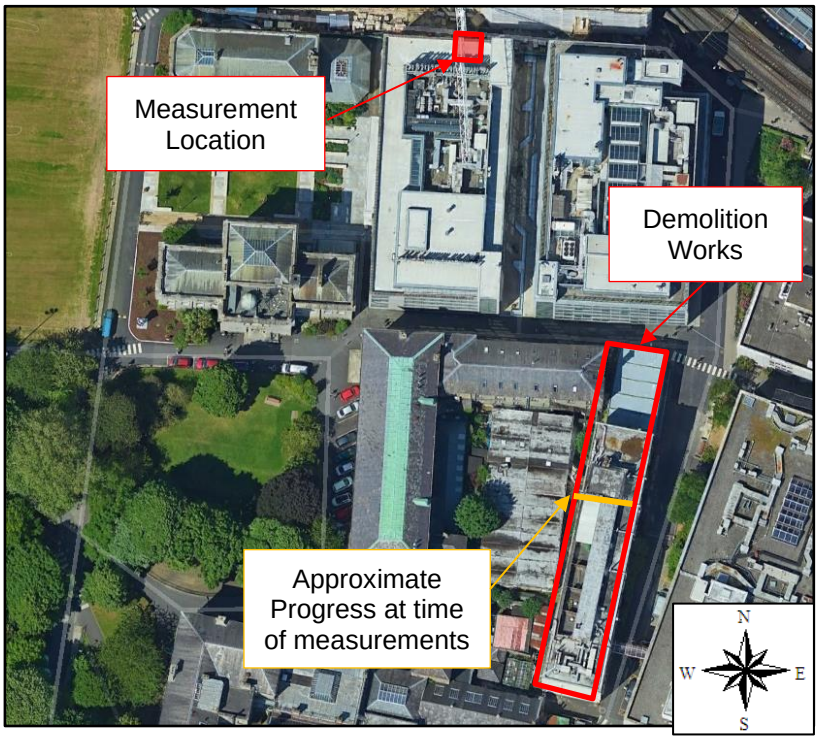

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Figure 3.14: Measurement Positions within Room 0.16 of the SNIAM Building

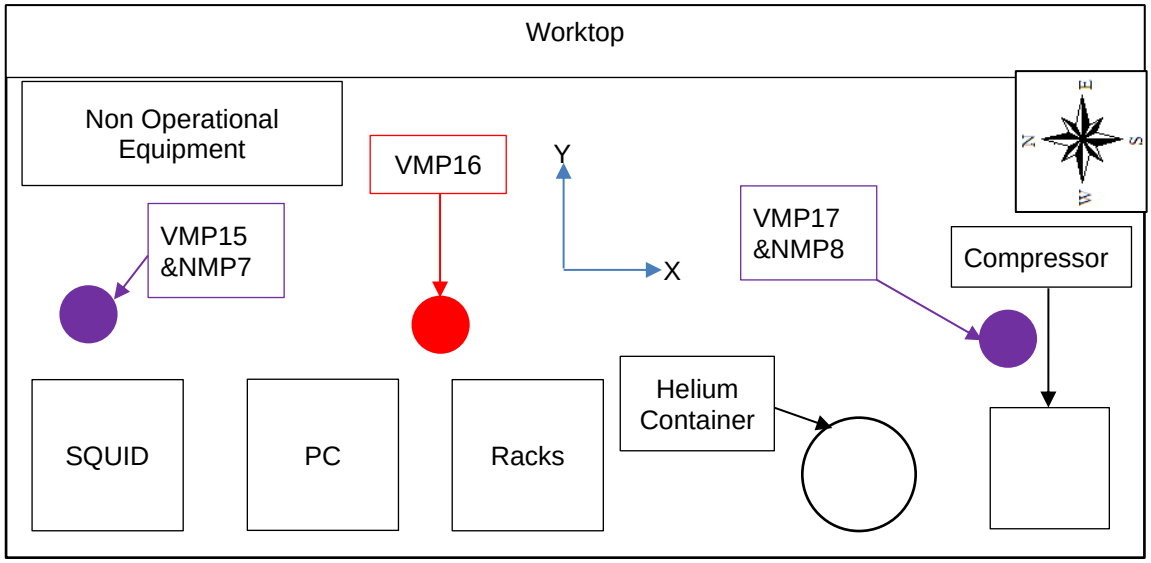

Table 3.21 identifies the results of the vibration monitoring at VMP15. **Table 3.22** identifies the results of a second set of vibration monitoring at VMP15 as the range of the measurement equipment was altered. **Table 3.23** identifies the results of the vibration monitoring at VMP16. **Table 3.24** identifies the results of the vibration monitoring at VMP17. **Table 3.25** identifies the results of the noise monitoring at NMP7. **Tables 3.26** and **3.27** identify the result of the noise monitoring at NMP8 with the compressor operational and the compressor idle, respectively.

The vibration baseline is based on a 30 minute period of the measurements for the first set of measurements at VMP15 and VMP16, which were carried out simultaneously. A 10 minute period has been utilised for the second set of measurements at VMP15 and the measurement at VMP17 which were carried out simultaneously. The noise baseline is based on a 30 minute period for NMP7 and a 10 minute period for NMP8.

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Table 3.21: Summary of Vibration Results for VMP15

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0003	0.0004	0.0004	0.0021	0.0032	0.0028
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0011	0.0006	0.0014	0.0037	0.0042	0.0042
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0035	0.0043	0.0045	0.0195	0.0256	0.0243
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0036	0.0036	0.0045	0.0192	0.0248	0.0239

Table 3.22: Summary of Vibration Results for VMP15 – second set

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0003	0.0003	0.0004	0.0015	0.0022	0.0018
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0011	0.0006	0.0014	0.0039	0.0035	0.0032
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0031	0.0034	0.0042	0.0129	0.0184	0.0177
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0032	0.0027	0.0041	0.0138	0.0182	0.0163

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Table 3.23: Summary of Vibration Results for VMP16

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0003	0.0004	0.0012	0.0024	0.0033	0.0068
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0017	0.0007	0.0067	0.0045	0.0040	0.0237
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0043	0.0044	0.0085	0.0217	0.0254	0.0464
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0058	0.0039	0.0174	0.0228	0.0250	0.0623

Table 3.24: Summary of Vibration Results for VMP17

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0003	0.0003	0.0011	0.0014	0.0022	0.0037
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0021	0.0016	0.0096	0.0038	0.0039	0.0142
Overall Velocity (0.4-31.5 Hz) mm/s	0.0038	0.0037	0.0075	0.0137	0.0182	0.0276
Overall Velocity (1-100Hz) mm/s	0.0071	0.0055	0.0225	0.0152	0.0189	0.0403

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Table 3.25: Summary of Noise Results for NMP7

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
61	95	67	96

Table 3.26: Summary of Noise Results for NMP8

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
64	91	69	91

Table 3.27: Summary of Noise Results for NMP8 (inactive compressor)

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
62	79	69	87

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3.8. SNIAM Building, High Speed Camera Lab

This room is located in the basement of the SNIAM Building. The sensitive equipment in the room included a high speed camera. Due to the position being located in the basement, the exact positioning in relation to the demolition works is not known.

The High Speed Camera was not operational during the measurement period. There was an air extract unit operational in the room which dominated the noise within the room. There was occasionally noise from the corridor from students and the closing of doors. This would be considered part of the baseline. It is unlikely that the demolition of the Biochemistry Building had a significant effect on the vibration levels in the room.

One vibration measurement position and one noise measurement position were utilised within the room:

- Vibration Measurement Position Eighteen (VMP18) was located adjacent to the tripod upon which the high speed camera was mounted;
- Noise Measurement Position Nine (NMP9) was located adjacent to the High Speed Camera on a tripod at a height of 1.5m.

Figure 3.15 identifies the approximate location of the measurements in relation to the demolition works. **Figure 3.16** identifies the positions of the sensitive equipment and measurement positions within the room as well as the directions of the X and Y axis for the vibration measurements, with Z being vertical.

Figure 3.15: Measurement Location with the High Speed Camera Lab in the SNIAM Building

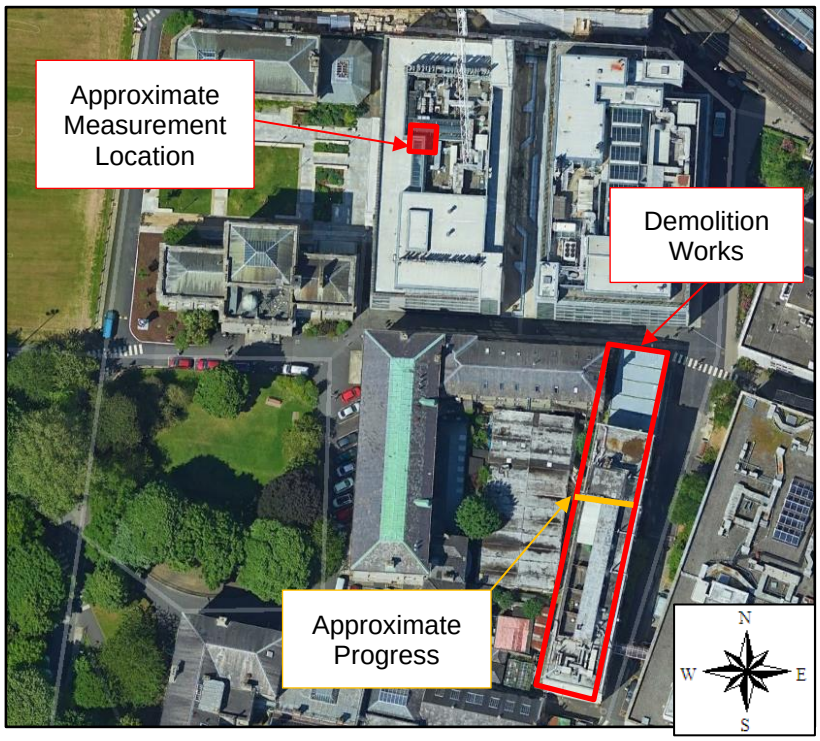

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Figure 3.16: Measurement Positions within the High Speed Camera Lab

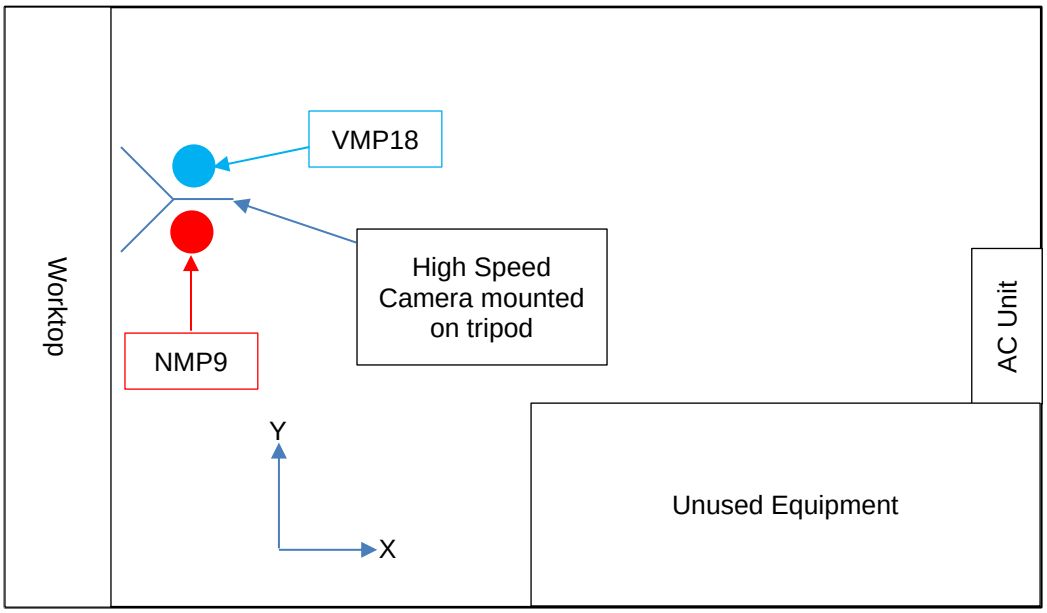

Table 3.28 identifies the results of the vibration monitoring at VMP18. **Table 3.29** identifies the results of the noise monitoring at NMP9. The vibration baseline is based on a 30 minute period of the measurements. The noise baseline is based on a 25 minute period of the measurements.

Table 3.28: Summary of Vibration Results for VMP18

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0002	0.0002	0.0002	0.0021	0.0018	0.0017
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0007	0.0005	0.0005	0.0025	0.0022	0.0023
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0028	0.0035	0.0034	0.0185	0.0157	0.0138
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0028	0.0024	0.0023	0.0185	0.0141	0.0125

Table 3.29: Summary of Noise Results for NMP9

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
40	75	53	76

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3.9. Panoz Building, Room B23/24, Scanning Electron Microscopes

These rooms are located in the basement of the Panoz Building. The sensitive equipment in the room included Scanning Electron Microscopes (SEM). Due to the position being located in the basement, the exact positioning in relation to the demolition works is not known. The SEMs were not operational during the measurement period. However, demolition activities were stopped for the majority of the measurement period to ensure a representative baseline could be recorded. Activities at the demolition site were observed both by ACCON and a member of staff from the Panoz Building throughout the measurement period.

There was occasional noise from adjacent rooms which included trolleys moving and lift movements. These activities may have affected the levels of noise and vibration within the room but are considered part of the normal baseline.

Two vibration measurement positions and two noise measurement positions were utilised within the room:

- Vibration Measurement Position Nineteen (VMP19) was located adjacent to one of the SEMs;
- Vibration Measurement Position Twenty (VMP20) was located 2m from VMP19;
- Noise Measurement Position Ten (NMP10) was located adjacent to one of the SEMs on a tripod at a height of 1.5m above VMP19;
- Noise Measurement Position Eleven (NMP11) was located 2m from NMP10 on a tripod at a height of 1.5m.

Figure 3.17 identifies the approximate location of the measurements in relation to the demolition works. **Figure 3.18** identifies the positions of the sensitive equipment and measurement positions within the room as well as the directions of the X and Y axis for the vibration measurements, with Z being vertical.

Figure 3.17: Measurement Location within the Panoz Building

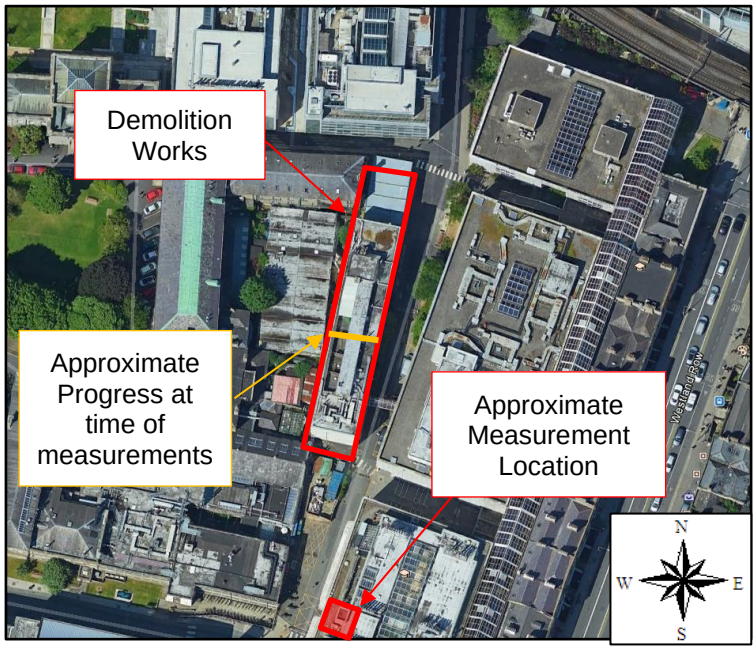

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Figure 3.18: Measurement Positions within Room B23/24 of the Panoz Building

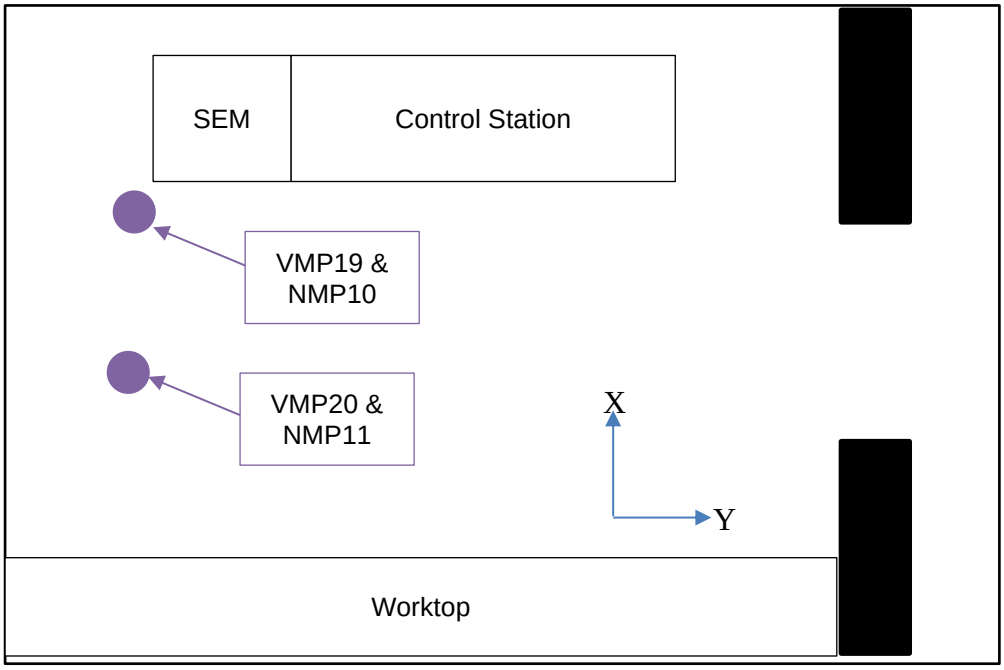

Table 3.30 identifies the results of the vibration monitoring at VMP19. **Table 3.31** identifies the results of the vibration monitoring at VMP20. **Table 3.32** identifies the results of the noise monitoring at NMP10. **Table 3.33** identifies the results of the noise monitoring at NMP11. The vibration baseline is based on a 30 minute period of the measurements. The noise baseline is based on a 25 minute period of the measurements.

Table 3.30: Summary of Vibration Results for VMP19

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0001	0.0001	0.0001	0.0004	0.0003	0.0002
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0002	0.0002	0.0002	0.0009	0.0007	0.0005
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0022	0.0024	0.0025	0.0071	0.0070	0.0076
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0011	0.0011	0.0011	0.0049	0.0040	0.0032

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Table 3.31: Summary of Vibration Results for VMP20

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0001	0.0001	0.0001	0.0004	0.0003	0.0002
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0001	0.0001	0.0002	0.0006	0.0005	0.0005
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0022	0.0022	0.0022	0.0075	0.0076	0.0063
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0011	0.0010	0.0010	0.0049	0.0038	0.0028

Table 3.32: Summary of Noise Results for Next NMP10

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
52	71	68	83

Table 3.33: Summary of Noise Results for Next NMP11

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
49	74	60	83

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3.10. Lloyd Institute, Room UB15/16, MRI machine

This room is located in the basement of the Lloyd Institute. The sensitive equipment in the room included a Magnetic Resonance Imaging (MRI) machine. The room was isolated from the adjoining corridor and the control room. Due to the position being located in the basement, the exact positioning in relation to the demolition works is not known. Additionally, due to the magnetic fields associated with the MRI machine it was not possible to place the measurement equipment in close proximity to the sensitive equipment. It was determined that vibration level within the control room would be a worst case in comparison to that in the MRI machine room and a position just inside the door of the MRI room would be safe for all items of equipment.

The MRI machine was not fully operational during the measurements (which would have increased the risk of damage to both the MRI machine and vibration measurement equipment). However, the system was pumping helium for the duration of the measurements which dominated the noise within these rooms.

It is possible that the demolition of the Biochemistry Building had an effect on the vibration levels in the room. However, observations of the demolition activities during the measurement period indicated that the majority of activities were occurring at the furthest part of the site from the Lloyd Building except for a single excavator which was moving material into waste bins. Demolition munching activities did not commence operation until the very end of the measurement period.

Figure 3.19 identifies the approximate location of the measurements in relation to the demolition works. **Figure 3.20** identifies the positions of the sensitive equipment and measurement positions within the room as well as the directions of the X and Y axis for the vibration measurements, with Z being vertical.

Two vibration measurement positions and one noise measurement position were utilised within the room:

- Vibration Measurement Position Twenty One (VMP21) was located on the inside of the MRI machine room;
- Vibration Measurement Position Twenty Two (VMP22) was located in the control room approximately 2m from VMP21;
- Noise Measurement Position Twelve (NMP12) was located within the control room approximately 1m from VMP21 on a tripod at a height of 1.5m.

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Figure 3.19: Measurement Location of the MRI room within the Lloyd Institute

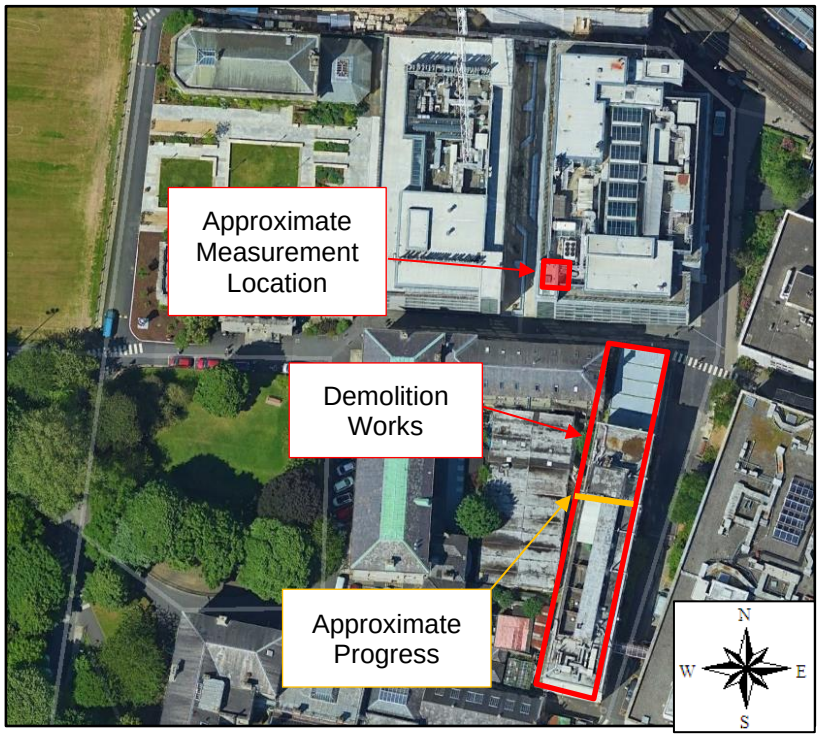

Figure 3.20: Measurement Positions within the Room UB15/16 in the Lloyd Institute

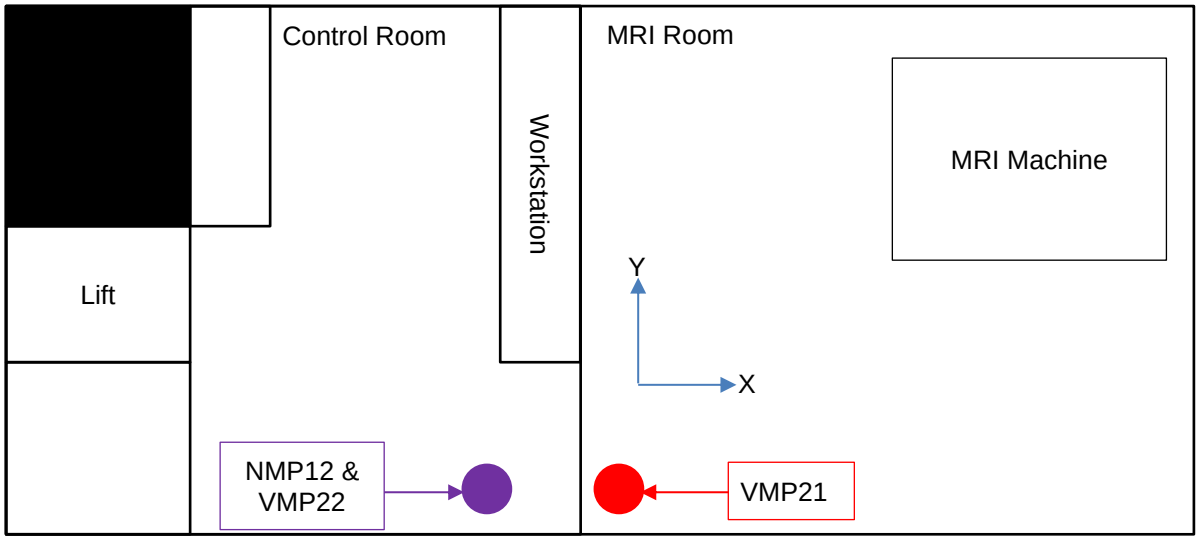

Table 3.34 identifies the results of the vibration monitoring at VMP21. **Table 3.35** identifies the results of the vibration monitoring at VMP22. **Table 3.36** identifies the results of the noise monitoring at NMP12. The vibration and noise baseline is based on a 30 minute period of the measurements. Analysis of notes made on site in combination with the vibration data has identified that trains on the DART line form part of the existing baseline vibration.

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Table 3.34: Summary of Vibration Results for VMP21

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0003	0.0002	0.0003	0.0028	0.0020	0.0027
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0004	0.0003	0.0007	0.0030	0.0022	0.0033
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0035	0.0030	0.0030	0.0245	0.0163	0.0191
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0030	0.0021	0.0025	0.0241	0.0150	0.0192

Table 3.35: Summary of Vibration Results for VMP22

Index	Average			Maximum		
	x	y	z	x	y	z
Overall Acceleration (0.4 Hz - 31.5 Hz) m/s^2	0.0004	0.0002	0.0003	0.0034	0.0020	0.0028
Overall Acceleration (1 Hz - 100 Hz) m/s^2	0.0011	0.0005	0.0074	0.0141	0.0085	0.0153
Overall Velocity (0.4 Hz - 31.5 Hz) mm/s	0.0047	0.0032	0.0032	0.0293	0.0265	0.0217
Overall Velocity (1 Hz - 100 Hz) mm/s	0.0044	0.0023	0.0122	0.0451	0.0268	0.0348

Table 3.36: Summary of Noise Results for NMP12

A-weighted Sound Level (dB)		C-weighted Sound Level (dB)	
$L_{eq,T}$	L_{peak}	$L_{eq,T}$	L_{peak}
49	79	63	81

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4. CONCLUSION

This report presents the results of the baseline vibration monitoring carried out at Trinity College, Dublin. This report has identified in detail the locations where vibration and noise was measured by ACCON during the baseline survey carried out between 19th November and 21st November 2019. The potential effects on the measurements of the onsite demolition and train movements on the DART Line have been identified for each measurement position. The report provides summary tables of the vibration and noise levels for each measurement position.

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