Environment Protection Authority Noise Camera Performance Assessment, Phase 2a – System Setup and Familiarisation

Final Report

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Executive Summary

This project took place during a period from July through December 2024. The project contract was fully executed in earlier Sept. 2024. The project intentionally overlapped with a project with an earlier start date but subsequent end date: *PRO24-18920: EPA Noise Camera Performance Assessment, Phase 1 – Scoping and Methodology Development*. While the Phase 1 project was underway, the Environment Protection Authority (EPA) progressed an RFQ to purchase four systems from UK supplier Intelligent Instruments (II).

Upon receipt of the four purchased systems, UTS were provided with one for evaluation purposes; this would become the system for which the subsequent (Phase 2b -– System Performance Evaluation) full lab-based performance assessment will be subsequently undertaken during 2025. To inform the EPA team of the performance of the system, gain confidence in the workflow, understand how to configure it, provide early feedback to II on functions, features and requirements etc., UTS proposed and were commissioned to undertake this Phase 2a in parallel with Phase 1. *Appendix A – Contract Details* includes a copy of the executed contract for this work. UTS were contracted to complete 6 days Lab testing supported by personnel time. Mr John Wassermann, EPA supported the UTS team. Findings from Phase 2a, as set out in this Final Report, could then be integrated into the *proposed* methodology for the subsequent Phase 2b.

This report is organised in a largely chronological fashion from the receipt of the system from the EPA in later June. Observations during the period from then until the completion of this report in late Nov 2024 are given. Conclusions are drawn based on the observations made along with recommendations for next steps.

Noise Camera delivery to UTS and Getting Started, June 2024

Initial unboxing, June/July 2024

The II Noise Camera system was delivered to UTS on Thurs 20th June, 2024. Four boxes in total were delivered with the contents of the boxes being unpacked and inspected by the EPA and UTS teams at the time. Included in *Appendix B – Noise Camera Supplier Packing List* is a full parts list. It is noted that clamps to attach the equipment to a pole were not included, since these will need to be traffic pole-specific.

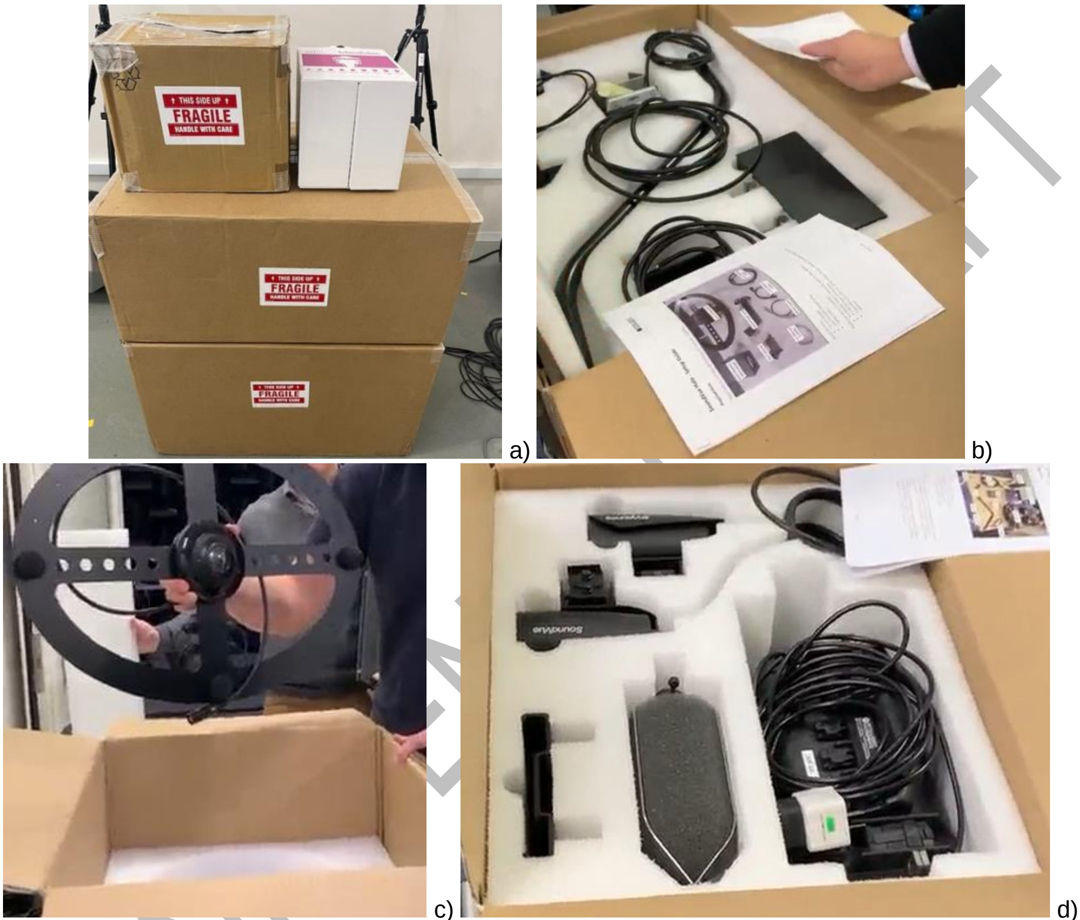


Figure 1 – Unboxing hardware upon receipt of system; a) all four boxes received, b) the SLM boom, Halo electronics, c) the Halo (source localisation) and d) the main electronics, ANPR cameras and wind shield

Upon subsequent inspection, it was immediately noted that one of the bulkhead connectors on the main box was loose as shown in Figure 2. Since it appeared trivial to resolve the issue, the EPA and II were informed and the system was opened from within the Pelicase, the bulkhead connector screw carefully re-tightened and the cover put back in place.

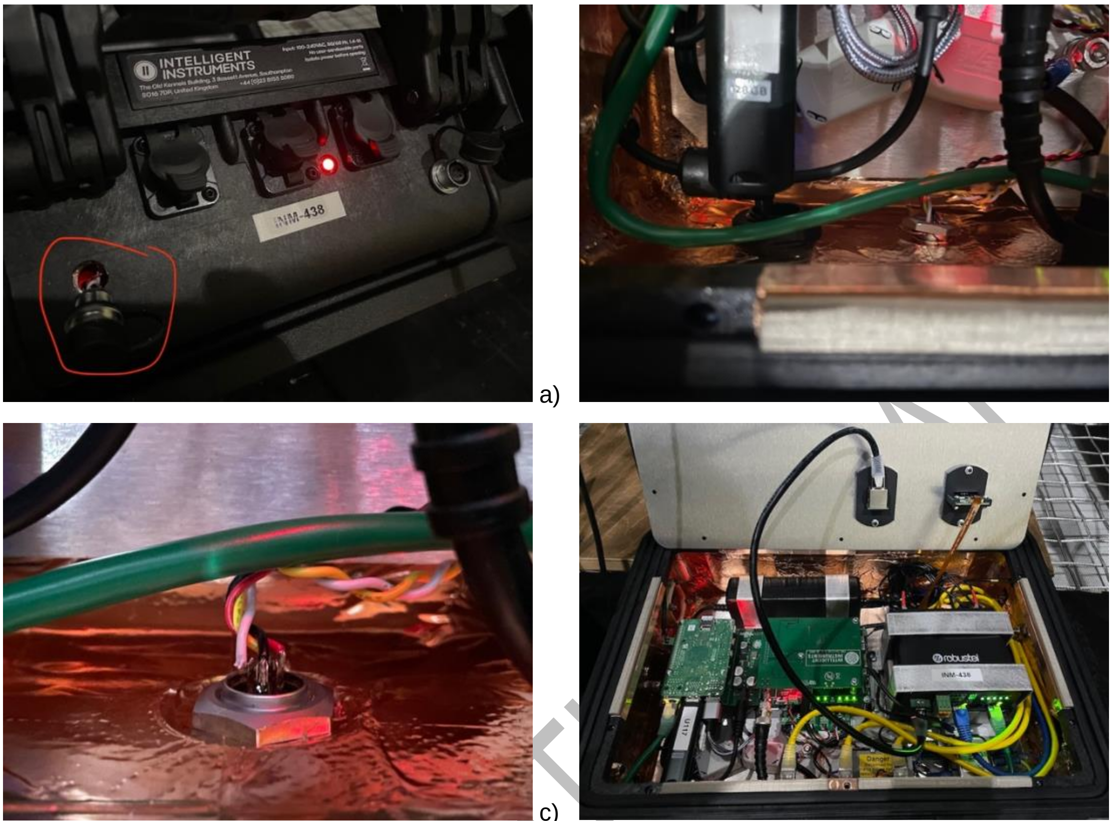


Figure 2 – Loose bulkhead connect discovered upon initial inspection of system; a) external as received, b) internal bulkhead half nut as received and, c) after repair and d) full internal after repair

Noise Camera interface logins for UTS and initial observations

II provided two sets of login details for key UTS project staff as follows:

1. **Login Details:** Intelligent Instruments has provided you with the username and password to log in to the Noise Camera portal. Here are the details:
Username: Benjamin.Halkon@uts.edu.au
Password: Button-11-Jumper

Username: Qiaoxi.Zhu@uts.edu.au
Password: Hungry-Axminster-447

URL: https://noisecamera.co.uk/login

Figure 3 – UTS login details for /noisecamera.co.uk/

Logging into the system Dashboard for the first time it was confirmed that there were eight example captures pre-loaded by II, as shown in Table 1 below.

Table 1 – /noisecamera.co.uk/ Events list interface showing sample eight pre-loaded captures

Events

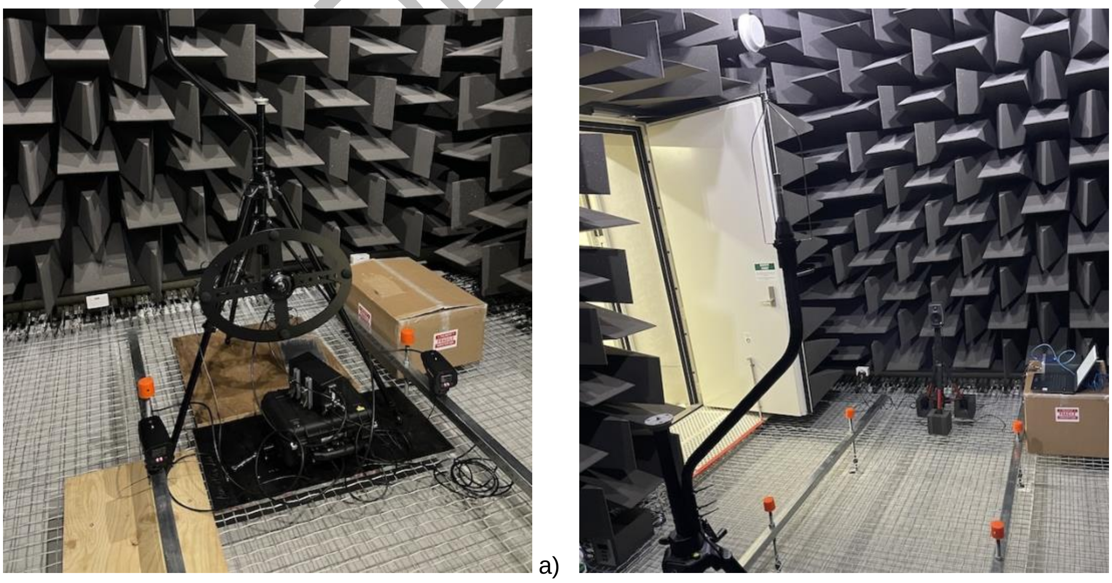
Search events

ID	Time stamp	Location	Number Plate	L_{Amax} Slow	L_{Amax} Fast	Audio ID	Notes	Action
131931	09-Jun-24 17:03	NSW Test Location	LK04PXS	97.5	101.9			
131990	09-Jun-24 23:46	NSW Test Location	HA12PSY	95.5	100.8			
132157	13-Jun-24 08:42	NSW Test Location	HW64BDU	88.6	90.9		Subaru	
132231	14-Jun-24 16:49	NSW Test Location	HA12PSY	94.8	98.6			
132303	16-Jun-24 06:03	NSW Test Location	CU61EEA	84.2	86.2			
132341	16-Jun-24 18:06	NSW Test Location	MJ13SFF	87.1	90.0			
132368	16-Jun-24 22:25	NSW Test Location	X20LDJ	92.9	96.0			
132389	17-Jun-24 08:36	NSW Test Location	HW64BDU	87.1	88.8			

Fully-Anechoic room testing period, late-June to mid-Aug 2024

Fully-Anechoic room configuration, July 2024

The system was initially setup in the Fully Anechoic Room. This was for convenience only, since this lab was more readily available than the Hemi-Anechoic at the time. As can be seen in Figure 4, the arrangement realised was for the sake of confirming functionality only – the various components only being connected together to produce a working system, not necessarily a practically viable solution. For example, the halo was attached to the legs of a tripod with the SLM microphone zip-tied to the tripod mast. The ANPR cameras were simply rail-mounted facing approximately toward the noise source. The setup led to image outputs in the /noisecamera.co.uk interface from the halo and ANPR cameras as shown in Figure 5 below.



a) b)

Figure 4 – Initial, functionality set-up in the Fully Anechoic Room; a) Noise Camera view, b) source view

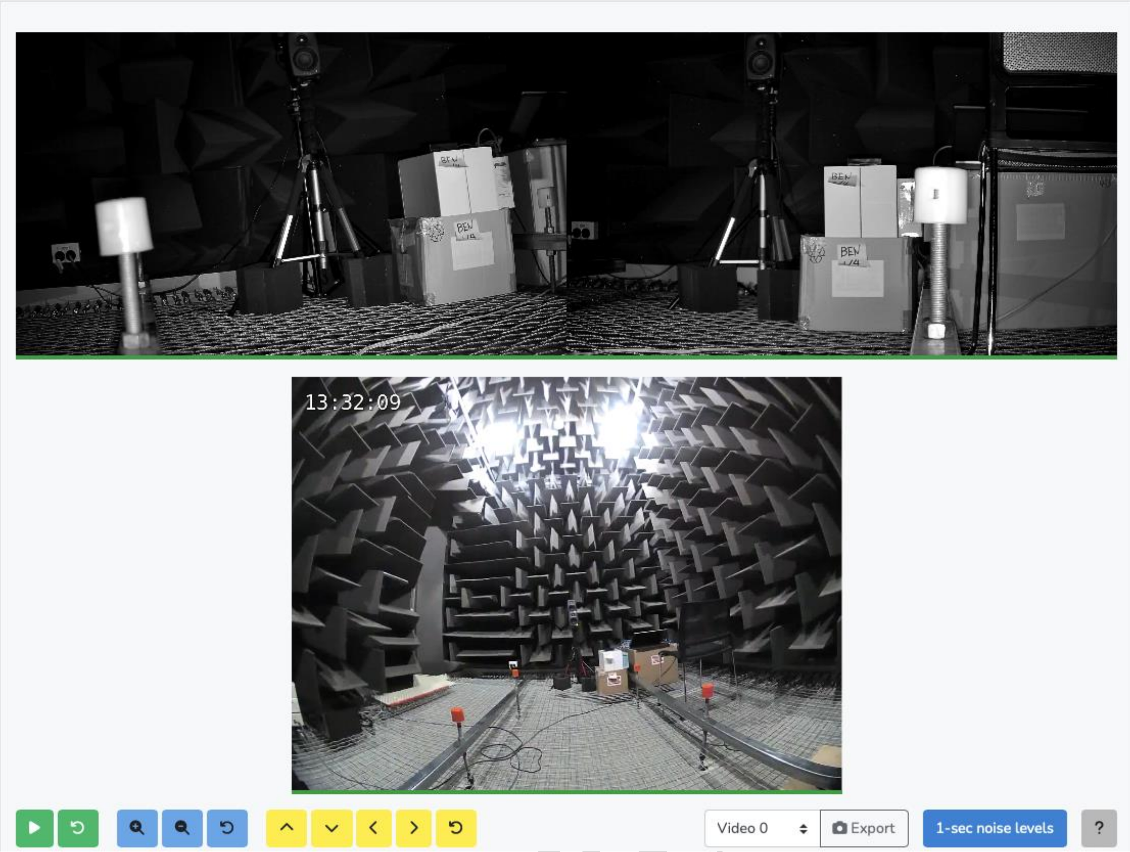


Figure 5 – /noisecamera.co.uk event interface showing Fully-Anechoic room camera outputs

Workplace health and safety documentation

As shown in *Appendix C – Project Risk Management documentation*, safety management documentation was necessary to be prepared for the safe use of the equipment within the Facility. The included document is one of three for reference. Additionally, A Research Safety Plan and a WorkPlan were prepared but are not included for the interest of brevity. All documentation has been reviewed by all lab users, including the originator and EPA representative, John Wassermann, and is approved by FEIT Safety and Head of School.

4G SIM/data connectivity challenges and workaround

Much of the first several weeks of this Phase was invested in trouble-shooting the 4G connectivity challenges that were experienced as a result of the system being in the UTS Acoustics laboratories where no reliable 3/4G network was available. The system was delivered with two 4G Telstra SIM cards installed. It was quickly identified that the UTS Acoustics Labs – a mobile Internet “blackspot” at the best of times – would not be conducive to the use of such a system which requires a stable connection to the Internet to operate. This issue would be especially compounded in the anechoic rooms where, when both sets of doors are closed, there is next to no mobile signal.

II suggested that, if UTS were able to connect the system to the UTS network, they expected to be able to connect to and control the Noise Camera. It is understood from conversations with II that the Noise Camera system sets up a VPN, over which they can then reliably connect, control the device and upload measurements. The UTS team expressed their doubts about this, given knowledge of the UTS IT security constraints. However, this was attempted as requested and several days to a week were invested in communications with II to unsuccessfully attempt to connect to the system.

As a workaround, the UTS team configured a 3/4G router in the Acoustics Labs Control Room/Foyer using one of the SIMs. A wired connection to the system was realised by routing an Ethernet cable to the device through the cable conduit. This seemed to be suitable and II were subsequently able to confirm connection.

Troubleshooting system correct configuration and cabling challenges

EPA had (wisely) colour-coded the system(s) upon receipt. The system delivered to UTS was marked with yellow dots on each of the individual system components and cables. Upon initial system set-up, some

Ethernet cable connections were made with reference to the yellow dots, rather than by paying proper attention to the II installation instructions. This was an oversight and meant that, while II were able to confirm connection of the system to the Internet, they were not able to see all devices, in particular the ANPR camera(s). Once the cables were connected to/from the correct ports, the system was shown to function as expected.

During the troubleshooting of the cable connection issues, it was observed on a number of occasions that II asked the UTS team on several occasions to re-seat the Ethernet cables in the bulkhead couplings, e.g.:

> *"Please would you re-seat the cable for camera #114 (into the Peli case), and also the cable that runs between the Peli case and the smaller Halo electronics enclosure (both ends). You should hear a click once they are pushed in fully. Let us know once this is done and we will check connection again remotely."*

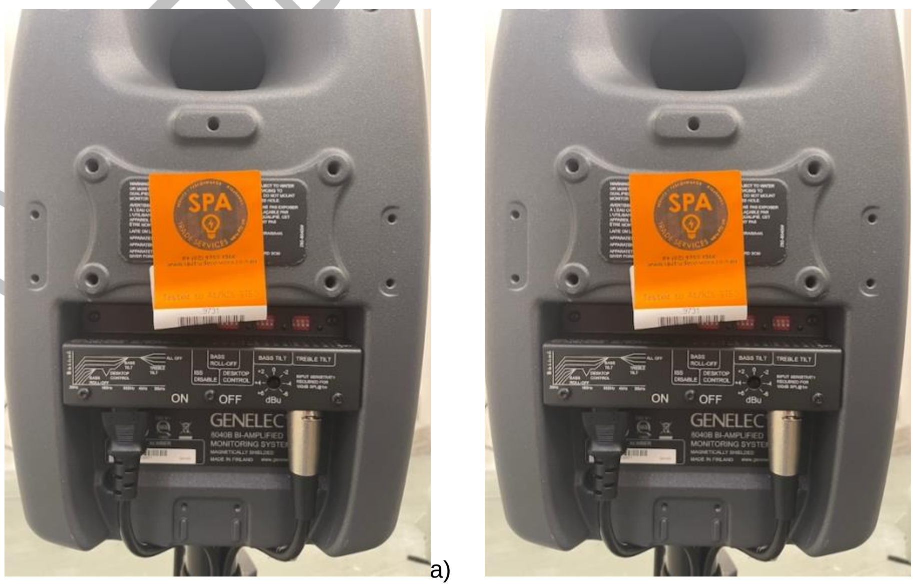
This was because it was being remotely observed that the system was not connected to one of the devices, often one of the ANPR cameras. The was unexpected, since the UTS team has plenty of experience with Ethernet (RJ45/50[1]) connectors, since they are regularly used on acoustics and vibration equipment. It is suggested that if there are these kinds of problems with device connectivity in a lab-based setting, there can be expected to be more challenges in a field-based scenario. This could be a point for discussion with II in the future.

Configuring a remote measurement system to enable out-of-hours testing and trouble-shooting

Given the challenges experience with trouble-shooting the initial system set-up, especially understanding when the system was connected to the II over the 4G network, a remotely operated solution was proposed which would include ethe use of a Siemens Simcenter Testlab data acquisition and processing system as the reference measurement and source control generator. This would enable out-of-hours use of the system over a remote desktop connection. Evening sessions to diagnose and troubleshoot the issues could then take place without a presence in the Lab being necessary. The acquisition system set-up can be seen in the Figure 4b to the right of the image. A close-up photograph is not available at this time. Furthermore, the Lab is equipped with an IP camera which can also be remotely viewed as necessary over a remote desktop.

Determining the levels of triggering for the Lab-based study

The initial set-up in the Hemi-Anechoic – as shown in Figure 4 – involved a pair (one shown) of *active*, Genelec 8010A studio monitor speakers (refer to Figure 6a) connected to each of the L and R channels of the soundcard output from the host laptop used for controlling the Siemens data acquisition system. Additionally, a pair of generator outputs from the Siemens system were T-pieced into the BnC cables to the speakers. With this configuration, both digitised sound files from the laptop (e.g. including those possible to be replayed from the /noisecamera.co.uk/ online interface) and more "traditional" signals – tones, white/pink noise, bursts, chirps etc. – were possible to be considered.



a) b)

Figure 6 – Genelec active bi-amplified studio monitor speakers; a) 8010A, b) 8040B

[1] RJ45 uses 8 pins, RJ50 uses 10 pins; both use the same connector.

Quite some trial and error was necessary to realise a system where the noise camera would reliably trigger with the sample events being replayed over the soundcard in the laptop. It took several weeks and two adjustments by II to the Noise Camera trigger triggering sensitivity before the Noise Camera would trigger from the UTS sources replaying the provided sample muffler pass-by sounds. This was, of course, because the sources and the speakers were not producing a sufficient level to overcome the trigger threshold.


a)


b)

Figure 7 – Alignment of reference measurement alongside Noise Camera SLM microphone; a) reference microphone in Fully-Anechoic room and b) reference EPA B&K Type 2250 in Hemi-Anechoic room

Triggering on tones (calibrator) and non-exhaust sounds; confirmation of SLM calibration

It was observed to not be an easy task to get the Noise Camera to trigger from other sound signals (white/pink noise, tones, etc.). This was expected, since the triggering includes “smart algorithms” to minimise the collection of events that are not muffler noise (birds, dogs barking, aircraft noise e.g.). When the software recognises a captured event as muffler noise, a muffler icon can be observed to the left of the entry in the Audio ID column in the Events page. Number plate recognition from the linked (DVLA in the case of UK systems) are also indicated by a wand icon to the left of the registration in the Number Plate column.

II were (understandably) somewhat sensitive about releasing details about the triggering mechanism and never released the trigger threshold values which they had adjusted the Noise Camera to. UTS provided them with insights into the levels that were being generated, based on the measurements from the reference measurement which was located alongside the Noise Camera SLM microphone, as shown in Figure 7 (for both the Fully-Anechoic and, subsequently described, Hemi-Anechoic room setup).

An early investigation in the Fully-Anechoic was to make a series of captures to attempt to confirm the performance of the sound level meter. The Certificate of Conformance for the system is included in *Appendix D – II Noise Camera System Certificate of Compliance*. Since it had previously been observed to be difficult to trigger a measurement with traditional signals, it was anticipated that, despite the 94 dB level, the UTS B&K Type 4231 microphone calibrator (1 kHz, 94 dB) would not trigger a capture. The UTS/EPA team, therefore, triggered the capture using muffler pass-by noise and then, immediately placed the calibrator on the Noise Camera SLM microphone. Several attempts were made with only the best one being retained in noisecamera.co.uk (Event ID #138068). The resulting measurement is shown in Figure 8. The B&K Type 4231 calibrator data sheets are included in *Appendix E – UTS B&K Type 4231 calibrator charts*, where it will be noted that the calibrator is overdue re-calibration. Prior to future Noise Camera performance evaluation research studies, the UTS Type 4231 calibrator should be sent back to the factory for recalibration.

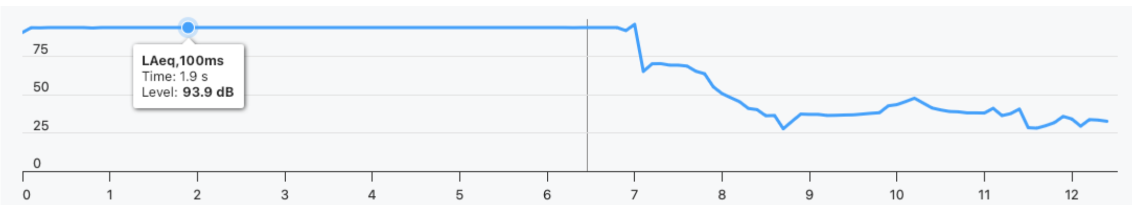
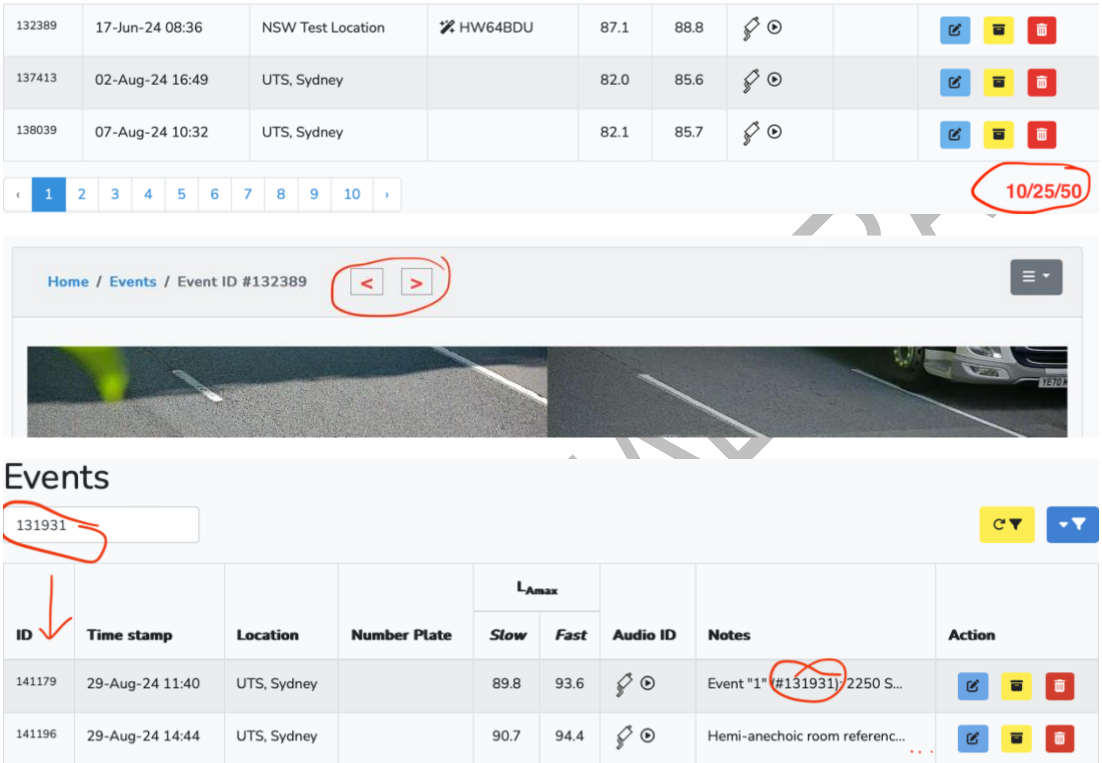


Figure 8 – Microphone calibrator B&K Type 4231 triggered measurement, showing expected performance

Software workflow improvement observations and suggested feature requests

While they may not be required/important for other II Noise Camera user cases, at least three opportunities for software interface improvements were observed, as are shown Figure 9. These feature requests should be easy to realise for II developers and would likely lead to significantly improved workflow for many of their customers, not only EPA. Being able to show on the Events page more than only 10 events would probably be a useful feature. Other such database-oriented interfaces often give the user the option to choose from a number of options, e.g. 10, 25 or 50 events in the list. Related to this, once the filter has been used to shortlist a number of events and these are being reviewed in detail in the event screen, it would probably be a useful feature to have backward/forward buttons therein so that the use can scroll back and forth between the shortlisted events without having to come back out to the Events list. Lasty, when searching e.g. for a particular event, e.g. one of the II provided samples, as shown in Figure 9c, it is suggested that the search tool should at least interrogate the ID field as well as Notes; this appears not to be the case currently.



a) b) c)

Figure 9 – Suggested software enhancements for improved workflow; a) option for 25 or 50 events within Events screen, b) option within each event to go backwards/forwards to previous/next event and c) missing search by event ID feature (here, the two hits are because the Notes inc. reference to 131931)

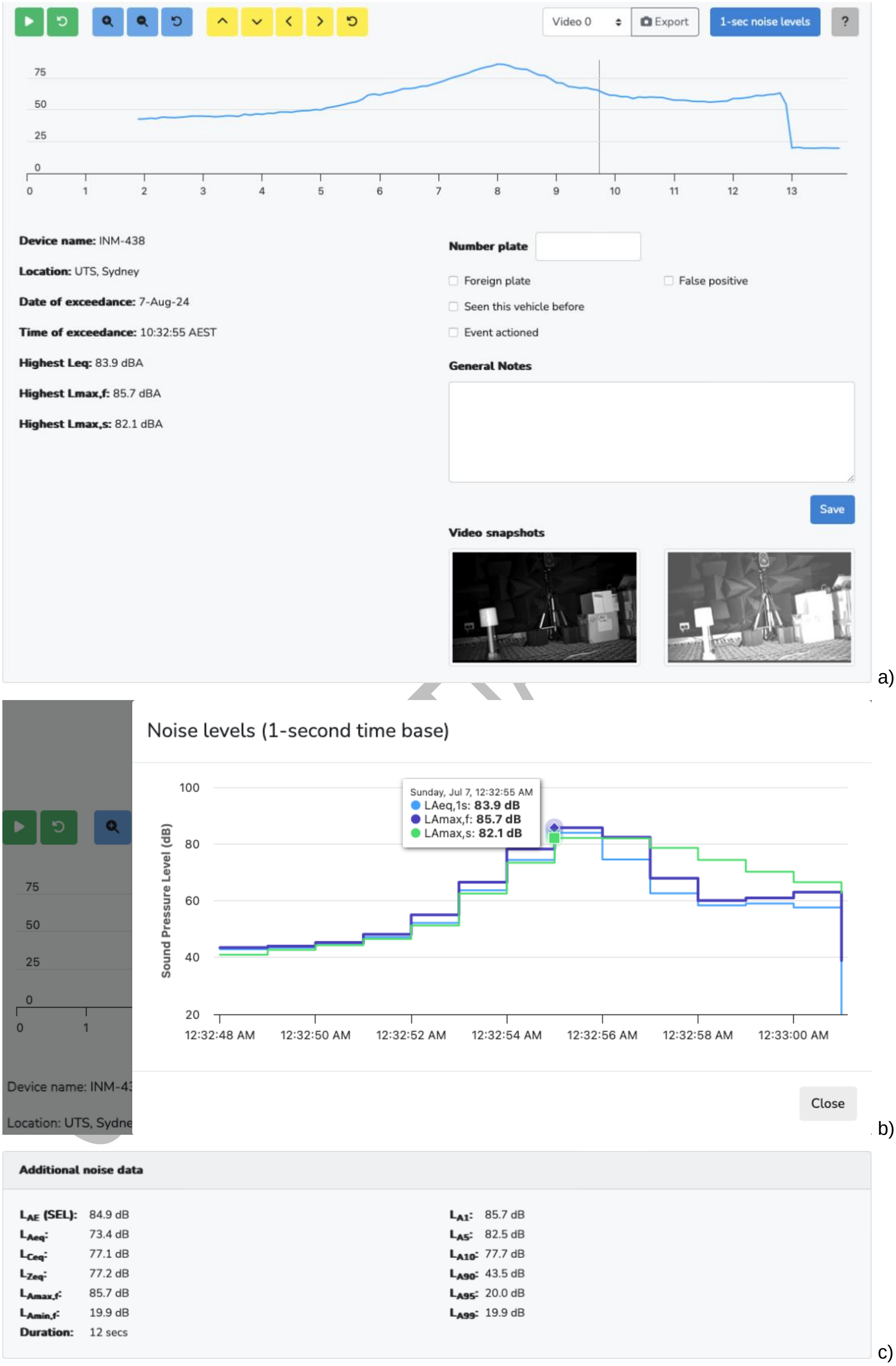


Figure 10 – /noisecamera.co.uk/ interface showing a) 100 ms and standard statistics data, b) 1-sec noise levels pop-out chart and c) additional, EPA-defined noise data statistical measures

Initial trials and observations form Fully-Anechoic Room, early Aug 2024

UTS were able to consistently produce new captures from early August 2024. Event ID #137413 is the first UTS event from the system using the two Genelec 4010A sources from the L&R channels from the laptop. On 7th August, further captures were made in a systematic manner, albeit with a Genelec 8040B in place of tone of the 8010A studio monitor speakers for a higher noise level over a wider frequency range. Figure 10 shows the user interface experience in /noisecamera.co.uk/ with 100 ms data given in a chart with a rolling cursor during playback. Blue zoom in/out and yellow cursor arrow buttons operate on all three video images simultaneously, enabling the user to extract an optimum image of the offending vehicle.

ANPR cameras automatically switch between say and night modes, depending upon the available ambient light. On occasions, the images are very dark. Videos (as shown in Figure 5) can be exported to .mp4 format by using the [camera] Export button to the right of the Video selection menu; when hovering on this, each of the three videos (0, 1, 2) for the two ANPR and the Halo camera respectively are shown. Video links can need to be refreshed if the screen has been open for some time. Occasionally, if left idle for an extended periods, the user will be automatically logged out and must log back in. “Meta data” and statistics for the capture are shown in the pane below the chart. The video frames are synchronised with the cursor on the 100 ms plot which can be played/paused and replayed from the beginning using the green buttons. 100 ms data are not possible to be exported from the interface at this time; this is being requested with II by EPA.

A 1-sec noise levels (L_{Aeq}, $L_{Amax,f}$ and $L_{Amax,s}$) pop-out chart, as shown in Figure 10b, is available by pushing the blue button. Here an automatic cursor will return the statistics at each 1-sec resolution data point for the three statistics. As can be observed, the Time of exceedance metric is given according to the peak noise level in the 1-sec data. While the time is given in the system local time in the metrics below the 100 ms data, the corresponding time in the 1-sec pop-out chart appears to be given in UTC (UK) time and, importantly, there appears to be an issue with the rendering of the month (out by one) in the pop-up cursor!

General Notes can be added to the free text field as well as a licence plate registration manually added (when not automatically determined), and some other contextual information checked on or off.

Initial level comparisons against SLM

Initial noise level investigations were made by comparing against a B&K Type 2250 Sound Level Meter (SLM) from UTS. The SLM microphone sensitivity was verified at the commencement of the measurement campaign against the UTS Type 4231 calibrator. Eight events numbered sequentially from 138086 to 138094 were capture by playing back each of the sample events provided by II in turn. It can take some time after capture for the recorded event to appear in the Events page and care must be taken to i) refresh the page regularly to ensure that all available captures are displayed and ii) ensure that the filter settings are not causing recently captures events to not be hidden. The Noise level (dB L_{Amax}) slider especially should be paid attention to. Summary count and Scatter chart, both available from the Dashboard, are other useful ways to view and sort events.

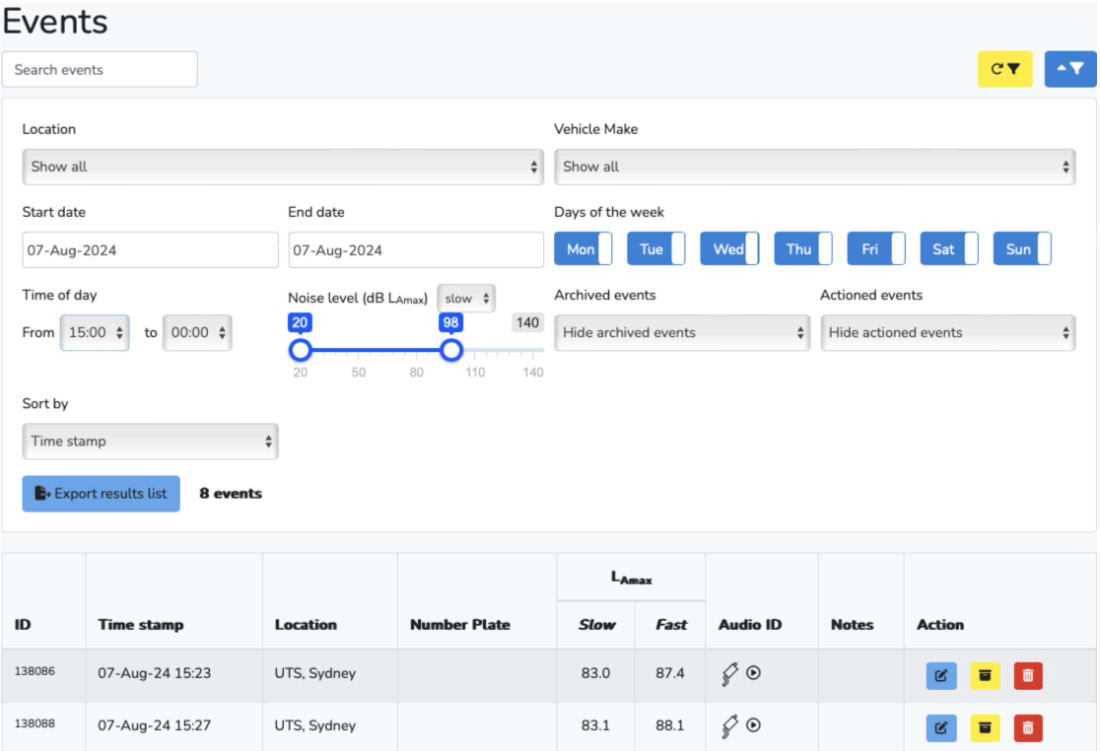


Figure 11 – Use of filtering in the Events list to show only the events of interest (eight found above but image cropped to show only the top two)

When used effectively, filtering is a powerful means, however, to show only the results of interest, as shown in Figure 11 above. Having filtered the events of interest, the statistics for the events in the list can be exported in the form of a .csv file into the Downloads folder (whichever folder is specified in the web browser in use for this purpose). Table 2 below shows the outcome of the export to .csv (*event_list_export.csv* is the default filename used; this is incremented with -1, -2 etc. for more exports), opened in Microsoft Excel.

Table 2 – /noisecamera.co.uk/ outputs for Events 138086 through 138094 created on 7th August 2024, a) first thirteen columns (Timezone (AEST), Location name (UTS, Sydney), Plate text (empty) and Plate text - automation (empty) hidden for brevity), and b) final ten columns ((General) Notes not used here)

Event ID	Time stamp (UTC)	Time stamp (local)	Highest LAeq,1s	Highest LAmax (fast)	Highest LAmax (slow)	LAE (SEL)	LAeq	LCeq	LZeq
138086	7/8/2024 5:23	7/8/2024 15:23	82.8	87.4	83	85.2	73.8	76.2	76.3
138088	7/8/2024 5:27	7/8/2024 15:27	84.7	88.1	83.1	85.3	73.8	76.1	76.2
138089	7/8/2024 5:28	7/8/2024 15:28	78.2	79.1	78	84.7	73.3	83.7	84.1
138090	7/8/2024 5:29	7/8/2024 15:29	84.9	88.6	84.6	87.6	76.1	79.5	79.6
138091	7/8/2024 5:32	7/8/2024 15:32	78.7	80	78.4	82.9	71.8	80.2	80.4
138092	7/8/2024 5:34	7/8/2024 15:34	76.8	78.4	76.6	81.8	70.4	83.6	84
138093	7/8/2024 5:37	7/8/2024 15:37	82	83.8	80.8	83.5	72.4	79.2	79.2
138094	7/8/2024 5:38	7/8/2024 15:38	77.3	78.6	76.9	84	72.9	84.3	84.6

a)

Event ID	LAmax (fast)	LAmin (fast)	LA1	LA5	LA10	LA90	LA95	LA99	Duration (secs)	Notes
138086	87.4	19.9	87.4	82	75.7	42.2	41.3	19.8	12.7	
138088	88.1	19.9	87.5	82.1	76.6	43.7	20.2	19.6	12	
138089	79.1	19.5	79.1	78.5	78	58.1	20.1	19.6	12.9	
138090	88.6	19.9	87.5	85.2	80.2	56.3	56	55	12.1	
138091	80	19.7	79.8	79.3	77.8	20.1	19.9	19.7	11.9	
138092	78.4	19.8	78.4	77.3	76.2	20.2	20	19.6	12	
138093	83.8	19.9	83.9	81.8	77.9	20.3	20	19.9	11.3	
138094	78.6	19.5	78.2	77.6	77	65.7	20	19.6	11.3	

b)

Since Logging and Advanced logging were not available with the UTS B&K Type 2250 SLM, comparative measurements were manually recorded following each capture. Triggering of the SLM measurement was similarly manually invoked to coincide with the start of the playback. For this reason, as well as that it is not known *exactly* how II start to process their statistics, the preliminary comparisons included in Table 3 below are included only for general information purposes and should not be published/shared with II. Subsequent performance evaluation will need to focus on how to ensure both measurements and processing of statistics are synchronised if uncertainty between them is to be removed. Lastly, at this stage, L_{Aeq} measurements were not collected from the 2250 SLM so, for this exercise, only $L_{Amax,f}$ and $L_{Amax,s}$ are compared.

Table 3 – Initial comparisons between II Noise Camera and UTS B&K Type 2250 statistics; Fully-anechoic

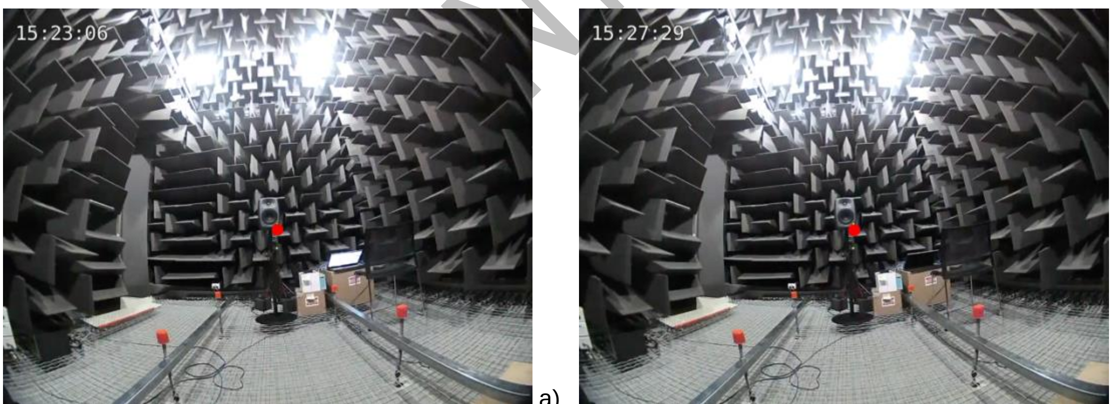
		Metric	LAmax,f			LAmax,s		
#	Event ID	Source Eve	II Noise can	UTS 2250	Delta	II Noise can	UTS 2250	Delta
1	138086	131931	87.4	87.25	0.15	83	82.75	0.25
2	138088	131990	88.1	87.8	0.3	83.1	82.9	0.2
3	138089	132157	79.1	78.7	0.4	78	77.7	0.3
4	138090	132231	88.6	88	0.6	84.6	84.3	0.3
5	138091	132303	80	78.7	1.3	78.4	77.7	0.7
6	138092	132341	78.4	77.7	0.7	76.6	76.2	0.4
7	138093	132368	83.8	83.4	0.4	80.8	80.5	0.3
8	138094	132389	78.6	77.8	0.8	76.9	76.7	0.2

Despite the constraints of this exercise as described above, reasonable agreement is observed between the two measurements systems in most cases as shown, noting that the II system over-estimates. Conditional formatting has been used to highlight in red where deltas between the Noise Camera and the 2250 SLM are greater than 0.5 dB(A); this threshold is arbitrarily chosen. Agreement as to what difference is to be considered acceptable between the Noise Camera metric and that of the reference measurement should be discussed and agreed in advance of or during the future full performance Evaluation research project.

It is unclear, for these selected statistics, why there would be greater differences in some cases and not in others, since triggering and clutter (multiple sources of noise/higher background noise levels, as is the case for some of the sample files provided by II), should not have such an impact for these particular max measures. Conversely, for the L_{AE} (SEL), L_{Aeq} etc. data, such differences in triggering and start of processing should be expected to lead to larger difference in statistics. This is to be subsequently explored.

Initial localisation observations

Initial observations of the ability of the Noise Camera to localise the source, as shown in Figure 12, are the at it appears to identify the source to the lower right, rather than the centre of the speaker primary cone. Without a gold standard reference source localisation measurement against which to compare, it is not possible to say whether this is or is not the location of the highest sound pressure level (SPL) for each event.



a) b)

Figure 12 – Initial source localisation observations; a) Event 138086, and b) mast mock-up

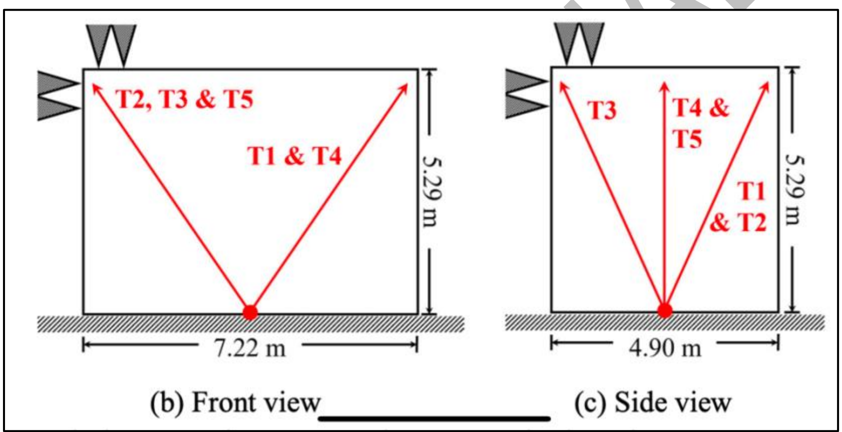
Hemi-Anechoic room testing period, mid-Aug to late-Nov 2024

Mast manufacture for Hemi-anechoic room installation

There was an increasingly pressing requirement during July and August 2024 to enable to the EPA Marketing and Comms. team to come to the UTS to collect/generate content for subsequent media releases. This was not appropriate with the functionality check configuration that was realised in the Fully-Anechoic room and the need to move the system to the Hemi-Anechoic was increasingly urgent.

The installation would require a traffic/power pole mock-up of some form to enable the realisation of a set-up that would be more aligned with an actual configuration for the field trial based systems. Constraints in the Heme-Anechoic room include the room dimensions, as shown in Figure 13a. While the maximum height before the foam wedges is 5.29 m, there are lights, sprinklers, cameras and other services protruding below the wedges so the target maximum height for the mast mock-up was ~5 m.

A candidate heavy duty tripod, suitable for sensor heads on the order of 10-20 kg mass was identified as a base for the pole mock-up. The tripod includes a cranked pylon which can extend the height range of the tripod by circa 1.5 m. A bespoke adaptor was manufactured to enable the tripod pylon to be firmly connected to a 4.5 m length of aluminium circular hollow cross-section tube (80 mm x 3mm thickness). The equipment was connected via the included brackets using stainless steel pipe clamps sources from Bunnings at two different lengths/diameters (78-102 and 105-127 mm). The ultimate arrangement, stored to the corner of the room, is shown in Figure 13b below. It is noted that the Halo electronics box (to the rear of the pole) and main electronic box should be installed such that the connectors are pointed downwards. Zip-ties and/or cable conduit should be use to root/protect the cables. In a field setting, the multiple component nature of the II Sound Camera solution makes it a potentially simple task to tamper with and/or vandalise the hardware.



a)


b)

Figure 13 – UTS mast within Hemi-Anechoic room; a) room dimensions and b) mast mock-up

Hemi-Anechoic EPA Marketing content collection, mid August 2024

Moving the system into the Hemi-Anechoic room for the EPA Marketing content collection exercise lead to an issue occurring with an Ethernet connector for one of the ANPR cameras. It was potentially a user-error induced issue, since a number of inexperienced support staff were called in to assist with the relocation of the set-up from the Fully-Anechoic. The weatherproof Ethernet connectors in the system were observed to be potentially difficult to disconnect, especially in the scenario in the Lab where low light levels persisted. One cable connector came apart upon disassembly and may have become improperly seated in the bulkhead fitting upon reconnection. Ultimately the connector had to be replaced. Upon doing so, proper connection to both ANPR cameras was observed. However, in the weeks afterwards, intermittent right side ANPR connectivity was observed with, again, II recommending for the cable to be re-seated in the connector. It remains unclear why these RJ45/50 connections are somewhat temperamental and this is a future risk.

Following several takes, marketing content including four grabs totalling 1m25s and video overlay of 4m05s were ultimately collected on 15th Aug 2024:

- https://vimeo.com/1002988012/99d23f37d6?share=copy
- https://vimeo.com/1000323456/94617a9eb6?share=copy

Hemi-Anechoic set-up

Given the source level challenges observed in the Fully-Anechoic room scenario with the Genelec studio monitors, (omni-directional) B&K Type 4929-L OmniPower Sound Source and matched B&K Type 2734-A Power Amplifier, as shown in Figure 14, were used in the Hemi-Anechoic – a much larger volume. The speaker was trip-mounted at a height of approx. 1 m from the floor. Adjustable gain controls on the amplifier would allow much improved control of levels within the volume from an externally generated signal (again, playing back the sample recordings from the II /noisecamera.co.uk interface). Additionally, the amplifiers have built-in pink and white noise generators which can be used as background noise. Furthermore, the use of multiple such sources (three in total available at UTS) would subsequently allow adjustment of levels of multiple sources, and of ambient noise. Repositioning of the various sources would further enable investigations into source localisation for increasingly acoustically complex scenarios.

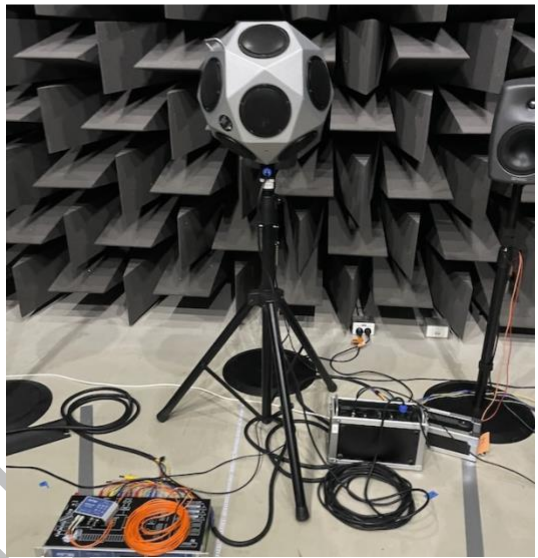

a)

b)

Figure 14 – Hemi-Anechoic room setup a) Noise Camera with adjacent reference B&K Type 2250 SLM and b) B&K Type 4929-L OmniPower Sound Source and matched B&K Type 2734-A Power Amplifier

For this series of measurements, the EPA B&K Type 2250 SLM was made available as it includes Logging and Advanced Logging licenses such that raw time series data could be recorded (as well as statistics – only available on the UTS system). This would enable subsequent post-processing of measurements to allow better alignment of reference measurements with the II Noise Camera and, therefore also, better agreement verification between systems for statistical measures, enabling II system performance validation.

Each of the eight sample data recordings were replayed from an Internet-connected PC via the omnidirectional source. The list of captures, 141196 through 141203 sequentially is shown in Table 4 below.

below. Figure 15 shows the room layout where only omnidirectional source shown to the centre is in use, despite the other monitor speakers arranged in the room which were in use for an alternative experiment taking place around the same time as this exploratory campaign. In the future performance evaluation research project, there will be no such additional instrumentation in the Lab. Since the light level is low, the ANPR cameras are not in night mode, hence the low level in those images. In the future, a rego plate should be placed in the field of view to confirm that the cameras capture the details at varying light levels in practice.

As can be seen in Figure 15, the localisation algorithm again shows the source to be to the bottom-left of the speaker. This is consistent across captures and is best case when the source is at peak level.

Table 4 – List of Noise Camera captures for analysis and post-processing to compare with Type 2250 SLM

141196	29-Aug-24 14:44	UTS, Sydney	90.7	94.4	
141197	29-Aug-24 14:44	UTS, Sydney	90.2	94.2	
141198	29-Aug-24 14:45	UTS, Sydney	91.3	93.3	
141199	29-Aug-24 14:45	UTS, Sydney	91.7	95.2	
141200	29-Aug-24 14:46	UTS, Sydney	89.4	91.5	
141201	29-Aug-24 14:47	UTS, Sydney	86.7	89.9	
141202	29-Aug-24 14:47	UTS, Sydney	90.1	92.7	
141203	29-Aug-24 14:48	UTS, Sydney	91.5	94.2	

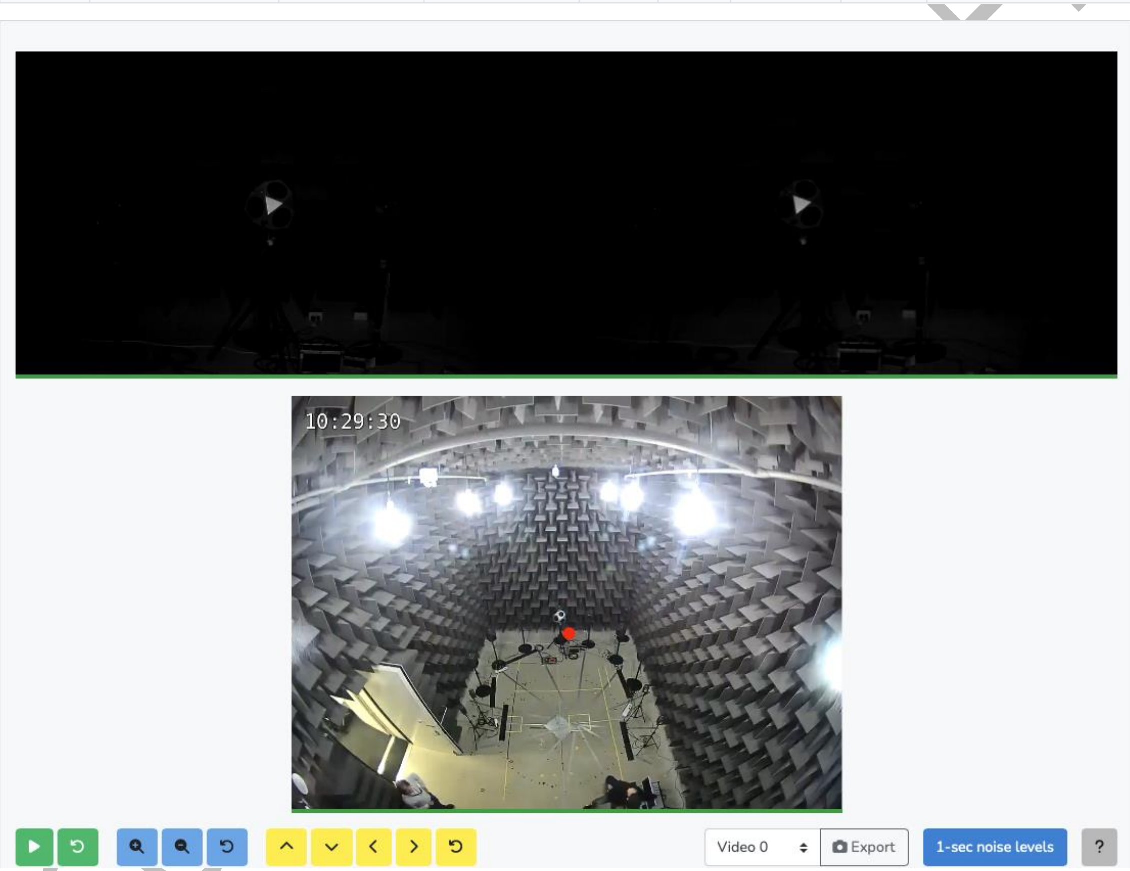
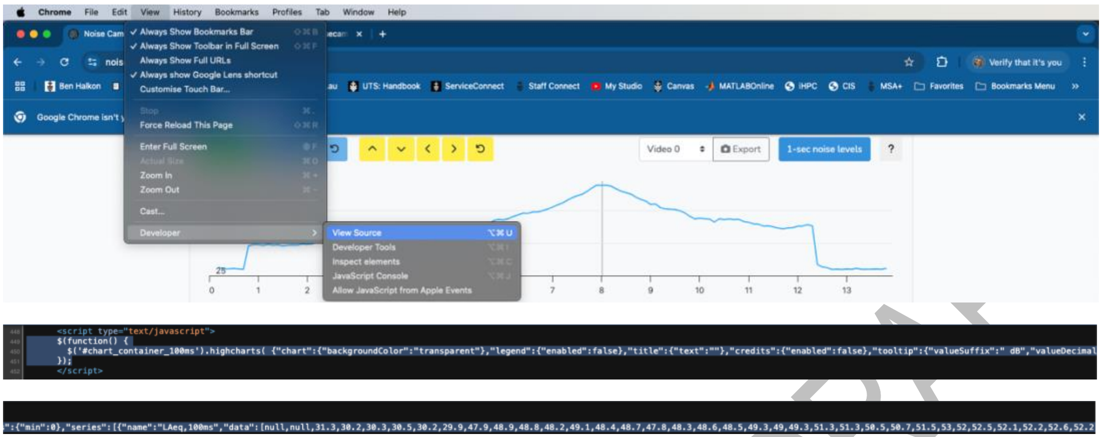


Figure 15 – /noisecamera.co.uk event interface showing 29th Aug 24 Hemi-Anechoic room camera outputs

Hemi-Anechoic room example sound level data processing

In the absence of a means to save or export the 100 ms L_{Aeq} data, these were manually exported from the /noisecamera.co.uk/ interface by accessing the HTML Source code used to produce the interactive plot, as shown in Figure 16. Equivalent data were subsequently extracted from the Type 2250 SLM measurements using their post-processing software interface, Measurement Partner Suite. The Type 2250 SLM microphone sensitivity was verified against the UTS Type 4231 calibrator prior to commencement of the measurement campaign. The two datasets were subsequently manually aligned for each measurement based on the time step or sample at which the metric peak occurred. The was a quite inefficient, time-consuming process.

An improved, semi- or fully-automated process should be developed in the future for an extended Noise Camera performance verification exercise. The support/input of II will be required to understand how they produce their statistics in order that the processing of the reference measurement for comparison can be completed in an equivalent way such that post-processing uncertainties are eliminated. Figure 17 shows an example of this alignment for “Event 1”. Other corresponding data are included in *Appendix F – Manually* *aligned data for Noise Camera vs. B&K Type 2250 SLM*. As can be seen, manual alignment has led to good agreement between the 100 ms L_{Aeq} time histories in most cases. Unfortunately, however, an event labelling error has led to a discrepancy in the final capture between the Noise Camera measurement and that extracted from the 2250 (which is the same dataset as the second event). This compounds the suggested need for a better automated approach. It is also recommended as a result of these measurements and the problems with manually comparing them with their 2250 SLM equivalents that *Source* Event labelling is included in the field-of-view of the Halo camera when reproducing such measurements in the future.



a)

b)

c)

Figure 16 – Manual process developed for export of 100 ms L_{Aeq} data from /noisecamera.co.uk; a) the HTML Source from Google Chrome browser, b) identifying the code for the L_{Aeq} plot and c) copying values

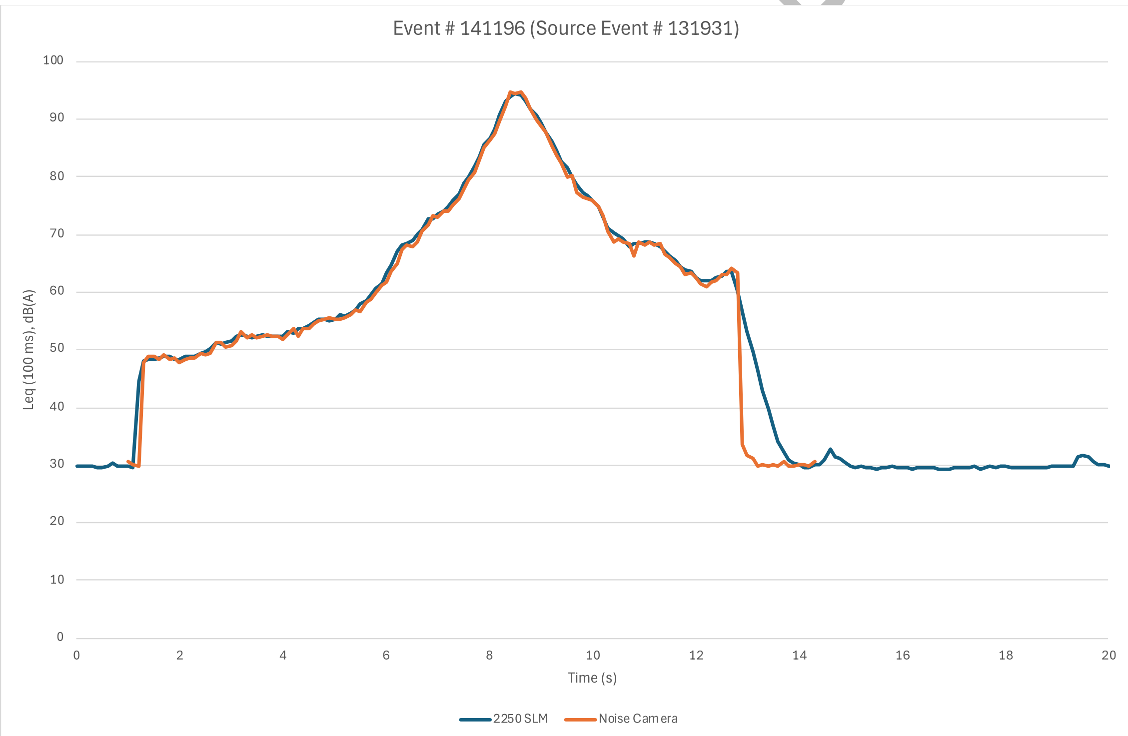


Figure 17 – Example comparison between Noise Camera and 2250 SLM data for Event # 141196

Table 5 – Comparisons between II Noise Camera and EPA B&K Type 2250 stats. – L_{Aeq}; Hemi-anechoic

		Metric	LAeq		
#	Event ID	Source Eve	II Noise Car	EPA 2250	Delta
1	141196	131931	94.39	94.6	-0.21
2	141197	131990	94.31	95.1	-0.79
3	141198	132157	93.34	93.4	-0.06
4	141199	132231	94.85	95	-0.15
5	141200	132303	91.63	92	-0.37
6	141201	132341	89.75	90.1	-0.35
7	141202	132368	92.61	92.8	-0.19
8	141203	132389	94.46	N/A	[redacted]

Comparisons between L_{Aeq} metrics for the II Noise Camera and EPA Type 2250 SLM are included in Table 5. Again, these preliminary observations are for internal reference purposes only and should not be published or shared with II for the reasons previously given. The processing approach should be improved and validated – in communication with II – prior to such results being utilised for formal purposes. Again, deltas greater than 0.5 dB(A) (arbitrarily chosen) are conditionally highlighted in red. It is noted that here the II Noise Camera systematically *under*-estimates vs. the EPA 2250 SLM.

Hemi-Anechoic multiple simultaneous sources preliminary investigation, Oct 2024

On 23rd October, a series of preliminary investigations utilising multiple sources were made. The intention of this final day of testing was to undertake some proof-of-concept scenarios which should inform the final stages of the preparation of the proposed *Phase 2b – Noise Camera Performance Evaluation* research project to be completed in the first half of 2025. This phase should take place once the field-based systems are also in service and observations of their performance are also being made. The findings of this report and that for the *Phase 1 – Literature Review and Methodology Development* should also have been reviewed and, as a first part of the Phase 2b project, any required updates to the proposed methodology can be made.

For this test day, the following mini-objectives were considered:

- Update Acoustics Labs Senior Technologist, Dr Qiaoxi Zhu on the learnings and observations on the /noisecamera.co.uk/ software from the several days of lab-based work completed in July/Aug 2024,
- Investigate the use of an event information board to be within the filed-of-view of the Halo camera, and,
- Experient with the use of multiple sources to preliminarily investigate system performance in terms of:
    - event triggering in the presence of increasing levels of ambient (pink) noise
    - localisation of primary/secondary source when multiple sources are used for various scenarios

SLM reference measurements for level comparison were not collected during this testing exercise.

As can be seen in Figure 17, the three UTS omnidirectional sources were arranged in the Lab on their tripods. The whiteboard to the left was intended to enable capture per measurement of the pertinent details relating to the scenario, in order that future post-processing would have clarity of the details. The reference measurement(s) – with the 2250 SLM e.g., given their time stamp, should therefore be easier to associate. It is observed that the information on the whiteboard needs to be clearer/larger for it to be legible from the Halo camera. In Phase 2b, it is recommended that a flat digital display be used on the floor of the Lab towards the camera. Such a set-up will be easier to write the pertinent information to (from the control room/lobby PC used to control the test) and will not cause significant additional reflections in the room.

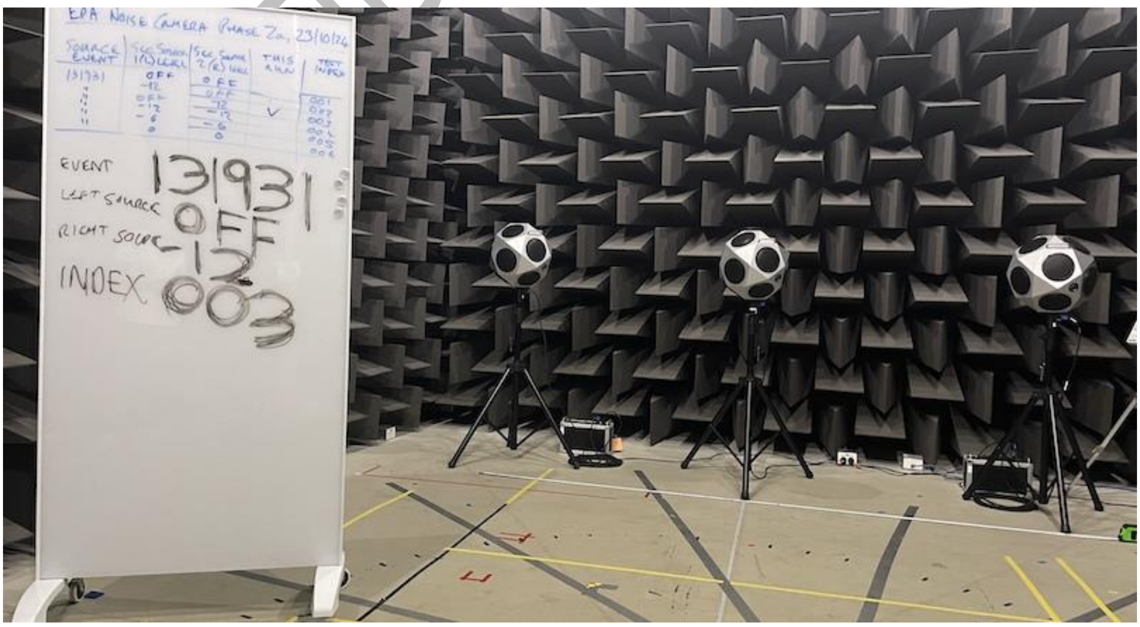


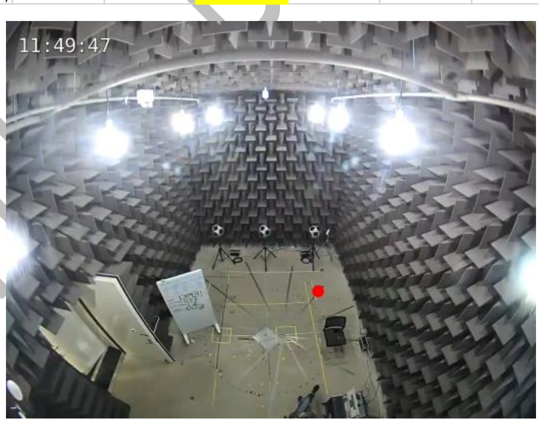
Figure 18 – Exploratory measurement scenario involving multiple omni-directional sources

As shown in Table 6, for this series of measurements, the same source capture, Event # 131191 was primarily used. This is a “clean” event with a single vehicle producing a peak L_{Aeq}, 1 s of 99.1 dB(A) with an ambient noise level of approx. 54 dB(A), as measured by the Noise Camera. The UTS set-up used enabled an 82.9 dB(A) equivalent to be readily realised, as shown below. A second source event # 132389 was used in two scenarios. This is a more “cluttered” event with a lane of crawling vehicles opposite, an offending vehicle peak L_{Aeq}, 1 s of 87.8 dB(A) and a background noise level of ~70 db(A).

Table 6 – List of scenarios in which multiple sources were used – 23rd October 2024

Event ID	UTS index	Time stamp (local)	Source event ID	(Secondary) source locations	Secondary source signal	Secondary source (L/Front) level	Secondary source (R/Rear) level	Highest LAeq,1s	Highest LAmax (fast)	Highest LAmax (slow)
149974	001	23/10/2024 11:24	131931	Tripod L/R (1500 mm	N/A	OFF	OFF	82.9	87.9	83.2
149976	002	23/10/2024 11:35	131931	Tripod L/R (1500 mm	Pink	-12 dB	OFF	84.2	87.5	83.1
149977	003	23/10/2024 11:49	131931	Tripod L/R (1500 mm	Pink	OFF	-12 dB	84	87.5	83.1
149978	004	23/10/2024 11:56	131931	Tripod L/R (1500 mm	Pink	-12 dB	-12 dB	87.3	90.5	86.2
149979	005	23/10/2024 12:02	131931	Tripod L/R (1500 mm	Pink	-6 dB	OFF	83.9	87.5	83.1
149980	006	23/10/2024 12:05	131931	Tripod L/R (1500 mm	Pink	0 dB	OFF	83.7	87.5	83.4
149982	007	23/10/2024 12:09	132389	Tripod L/R (1500 mm	Pink	-12 dB	OFF	87.1	89.2	86.1
149983	008	23/10/2024 12:14	132389	Tripod L/R (1500 mm	Pink	0 dB	0 dB	87.9	89.4	86.4
149984	009	23/10/2024 12:20	131931	Floor L/R (1500 mm)	Pink	OFF	-12 dB	85.5	88.2	83.9
149987	010	23/10/2024 12:23	131931	Floor L/R (1500 mm)	Pink	-12 dB	OFF	84.3	88.2	83.9
149988	011	23/10/2024 12:29	131931	Floor F/B (1500 mm)	Pink	OFF	-12 dB	84.3	89.7	85.1
149989	012	23/10/2024 12:33	131931	Floor F/B (1500 mm)	Pink	-12 dB	OFF	86.6	89.7	85.3
149991	013	23/10/2024 12:40	131931	Floor F/B (750 mm)	Pink	OFF	-12 dB	85.3	89.1	85.2
149992	014	23/10/2024 12:46	131931	Floor F/B (750 mm)	Event	Event	OFF	88.2	92.4	87.1
149993	015	23/10/2024 12:50	131931	Floor L/R (750 mm)	Event	OFF	Event	91.4	95	90.4
149994	016	23/10/2024 12:53	131931	Floor L/R (1500 mm)	Event	OFF	Event	91.9	94.3	90.3
149995	017	23/10/2024 12:54	131931	Floor L/R (1500 mm)	Event	OFF	Event -10 dB	87.9	90.6	86.3

a)



b)

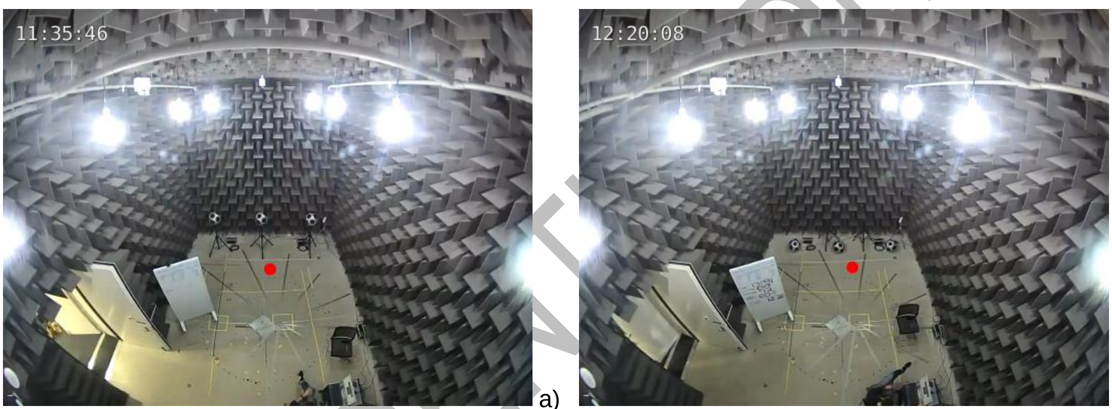
c)

Figure 19 – Comparison between localisation the presence of additional background pink noise; a) primary source only, at time of peak level (149974), b) R source at -12 dB at 3.1 s and c) L source pink noise at 0 dB at 6 s (149980)

In the first six captures, background pink noise levels for the additional L and R omni-directional sources were varied to attempt to preliminarily explore the impact on the ability of the Noise Camera to trigger and localise the source. No problems with capture triggering were experienced. As can be observed in Figure 19a, the Noise Camera identifies the location of the primary source effectively, again just to the bottom-right of the omni-directional source. This frame is from the time of peak level occurrence, i.e. 6.8 s. Figure 19b shows a frame for the event with UTS index 003 (149977) where the Right secondary source was outputting pink noise with a level of -12 dB and the Left source was OFF. The frame extracted is from 3.1 sec into the event, approx. 2 sec prior to the peak (from the primary source). At this time, the *total* noise level is ~62.2 dB(A). At 7.1 sec, the peak total noise level is 84 dB(A), as shown in Table 6. Figure 19c, conversely, shows a frame for the event with UTS index 006 (149980), i.e. where the Left secondary source was outputting an internally generated pink noise level at 0 dB (gain) and the Right was OFF. The frame extracted is from 6 sec into the event, approx. 2 sec prior to the peak (from the primary source). At this time, the *total* noise level is ~73.5 dB(A). At 8 sec, the peak total noise level is 83.7 dB(A), as shown in Table 6. Comparing Figure 19b&c, there seem some differences in the Noise Camera localisation performance left versus right of the frame which might be linked to the level of the additional source. There may be a virtual source scenario which could come about as a result of reflections of sound pressure from the floor.

The behaviour of the Noise Camera was as expected for scenarios where both L and R speakers had the same noise levels at times during the capture event prior to the primary source becoming the loudest source in the field-of-view. In the videos for events #UTS004 (149978) and UTS008 (149983), the red dot marker can be seen swapping between the L and R speaker and occasionally pausing *between* the two, i.e. at the primary source.

To explore the possibility of reflections of the sound pressure from the floor of the hemi-anechoic chamber having an influence on the localisation accuracy of the Noise Camera, events with UTS index 009 to 017 were completed with the omnidirectional sources removed from the tripods and placed directly on the floor. The frames extracted from the Halo in Figure 20 are for equivalent scenarios – *apart* from the location of the sources – UTS002 (14976) and UTS009 (149984), i.e. where the level of the Left secondary sources was set to -12 dB. In both cases, the frame extract is from the time of the peak noise level. Interestingly there appears to be little difference in the source marker between the two scenarios.



a) b)

Figure 20 – Comparison of localisation for a) tripod-mounted and b) floor-located sources

Continuing this preliminary investigation of localisation performance for the floor-located speakers, local and straightforward additional scenarios to explore were re-arranging the speakers in an array down the centre-line of the Lab, and to reduce the separation of the additional speakers from the primary from 1500 mm to 750 mm. Such scenarios are included in events with UTS indices 011 (149988) through 017 (149995). Behaviour was as expected for speakers located along the centreline, with the loudest source identified with the marker just to the bottom right. With the speakers moved closer together (750 mm spacing) in UTS013, the marker appears closer to the wrong source. Since vehicle exhausts are generally not closer together than 750 mm, it is not expected that this is a limitation of the system in practice.

From UTS014 to 017, rather than pink noise, the secondary source was given the same input signal as the primary source speaker. In this case, some level-dependent swapping of the marker is observed as expected. The loudest source at any one time during the course of the event appears to be properly identified.

Spurious system triggering/event detection

On some occasions, in order that II could connect to and diagnose the system between UTS exercises, that the system remained powered up. During such times, when other activities were taking place within the Lab, spurious triggering of non-exhaust noise events was observed. E.g. from 13th Sept through 24th Sept, a number of measurements were made. These should be deleted in the Noise Camera interface and II asked to confirm that these measurements are not retained in their system.

Conclusions and summary of observations and findings

This Set-up and Familiarisation project has served the intended purpose. As a result, the UTS and EPA teams are now more familiar with the behaviour and performance of the Intelligent Instruments (II) Noise Camera systems and software interface. Some challenges with hardware subtleties and reliability of components have been identified and some software interface workflow improvements identified. While a back-to-back full validation of captured levels, derived statistics and offending primary source localisation has yet to be completed – this being the purpose of the proposed subsequent *Phase 2b – Noise Camera Performance Validation* research project, initial investigations have shown that the performance is as expected when compared with equivalent measurement devices, namely a B&K Type 2250 Sound Level Meter (from a sound pressure level and processed metric standpoint) and knowledge of the physical scenario under investigation (from a source localisation standpoint).

During the period of evaluation, EPA colleagues have been able to engage with the process and, as a result, have been able to engage with II ahead of the planned field-trial phase of the initiative to ensure that the systems are as required in advance of them being field-deployed. UTS has been able to observe the function, workflow and expected performance of the Noise Camera in order that the proposed methodology for subsequent performance validation be informed. It is intended that this report serve as a useful reference guide to the UTS approach and what informed the various decision made during this Phase 2a project.

Appendix A – Contract Details and Scope of Services

Contract Details

Agency	Name	NSW Environment Protection Authority established under the *Protection of the Environment Administration Act 1991* (ABN 43 692 285 758)
	Division	Regulatory Practices and Services
	Address	6 Parramatta Square, 10 Darcy Street, Parramatta NSW 2150
Agency Authorised Officer *(refer to clause 23 - Notices)*	Name	Sonya Errington
	Position	Director - NSW EPA
	Address	6 Parramatta Square, 10 Darcy Street, Parramatta NSW 2150
	Telephone	02 9995 6928
	E-mail	Sonya.errington@epa.nsw.gov.au
Consultant ('You')	Name	University of Technology Sydney (UTS)
	Address	15-73 Broadway, Ultimo NSW 2007
	ABN	77 257 686 961
Your Authorised Officer *(refer to clause 23 - Notices)*	Name	Director. Research Office
	Address	PO Box 123, Broadway NSW 2007
	Telephone	02 9514 9681
	E-mail	RE@uts.edu.au
Services	Set up and troubleshoot a supplied noise camera in the UTS Tech Lab's anechoic chambers in collaboration with EPA and Intelligent Instruments UK Ltd. This involves resolving configuration and connection issues, experimenting with trigger thresholds and noise signal characteristics, and preparing a performance evaluation methodology; Prepare progress reports to inform the next phase of work based on findings, as described in **Schedule A – Services**	
Project title	EPA Noise Camera Performance Assessment, Phase 2a – System Setup and Familiarisation	
Key Personnel *(refer to clause 3.1(f))*	Name:	Dr Benjamin Halkon
	Position:	Associate Professor
	Telephone:	02 9514 9442/0416 843 253
	Email:	Benjamin.halkon@uts.edu.au
	Name:	Dr Sipei Zhao

Version 1.1

Position: Lecturer
Telephone: 0422 866 885
Email: Sipei.zhao@uts.edu.au

Name: Dr Qiaoxi Zhu
Position: Acoustic Technologist
Telephone: 0414 324 378
Email: Qiaoxi.zhu@uts.edu.au

Commencement Date *(refer to clause 2 - Term)*	01 July 2024

Schedule A – Services

Services: Name	Services: Description of Milestones/Deliverables	Performance Timeframe	Fee (excluding GST)	When to send invoice
Consultant Services (including Researcher time, Lab time, Technical and IT support and Regulatory reporting)	Noting that the proposed work is new and novel – not yet standardised – and needs to be done on a 'discovery' basis, where the findings of one phase of works will inform the next, UTS will complete the following tasks, in consultation/collaboration with EPA: • In consultation and collaboration with the EPA and preferred noise camera solution supplier Intelligent Instruments UK Ltd, set up and familiarise with a single supplied noise camera in the anechoic chambers at UTS Tech Lab. • Work with the UK-based supplier to troubleshoot the proper setup of the system to working order. This includes evaluating and managing the constraints imposed by the system being software-configured and managed remotely from the UK. • Conduct the subsequently required performance evaluation testing from UTS Tech Lab, NSW. • Resolve configuration and connection issues associated with the network to be able to reliably communicate with the system for the purposes of accessing recorded data. • Determine and experiment with the trigger thresholds and noise signal characteristics to enable quality and meaningful measurements to be made in the UTS Tech Lab Acoustics during the subsequent performance reliably and not excessively. • Determine the procedure, in collaboration with the UK supplier, for those measurement data to be made available through the specific noise camera location in the noisecamera.co.uk online Dashboard. • Use these proposed familiarisation studies and pre-investigations to inform the preparation of performance evaluation methodology based on observations of how the system operates and how data can be interrogated/reported. • Provide guidance and engagement with EPA. • Prepare meeting minutes, follow-up notes, and brief progress reports to inform the next anticipated phase of work – Phase 2b – System Performance Evaluation – based on the findings of this proposed Phase 2a.	1 July 2024 - 31 December 2024	$24,907.15 (comprising 8 days of work at $2,323.17/day or 56 hours of work at $331.88/hr) Work undertaken by EPA under direction of UTS will not be chargeable	Up to $24,907.15; to be invoiced on a regular basis, subject to completion of EPA-approved timesheets
	TOTAL FEE		**$24,907.15**	

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Appendix B – Noise Camera Supplier Packing List

Equip ID #	Equipment	ID / Group	Make	Identifier	Serial	Number # / Status / Notes
34	Microphone	Noise camera 4	Intelligent Instruments	INM438	352176	Delivered to UTS 20 June 2024
35	Preamplifier	Noise camera 4	Intelligent Instruments	INM438	84754	Delivered to UTS 20 June 2024
36	Microphone assembly	Noise camera 4	Intelligent Instruments	INM438	165243	Delivered to UTS 20 June 2024
37	Pelican box	Noise camera 4	Intelligent Instruments	INM438	N/A	Delivered to UTS 20 June 2024
38	Halo	Noise camera 4	Intelligent Instruments	0027	N/A	Delivered to UTS 20 June 2024
39	Electronics box	Noise camera 4	Intelligent Instruments	0027	N/A	Delivered to UTS 20 June 2024
40	Weather station	Noise camera 4	Intelligent Instruments	INM438	24130023	Delivered to UTS 20 June 2024
41	Camera LPR 1	Noise camera 4	Intelligent Instruments	114	N/A	Delivered to UTS 20 June 2024
42	Camera LPR 2	Noise camera 4	Intelligent Instruments	115	N/A	Delivered to UTS 20 June 2024
43	SIM 1	Noise camera 4	Telstra	INM438	8000471236507	Delivered to UTS 20 June 2024
44	SIM 2	Noise camera 4	Telstra	INM438	8000471235731	Delivered to UTS 20 June 2024

Appendix C – Project Risk Management documentation

UTS **FEIT HEALTH & SAFETY GENERAL RISK ASSESSMENT**

Activity name	NoiseCamera Performance Verification (PRO24-20112)	**Faculty**	FEIT	**School / Centre / Department**	SMME/CAAV
Activity description	This project will aim to evaluate the performance of a NoiseCamera for traffic excessive noise in the (hemi-)anechoic rooms in a controlled environment. Various source configuration will be used to evaluate the camera's ability to be triggered and to capture reliable measurement data including level, nature and position of sound source.				
Date of assessment	11/07/2024	**Version No.**	1	**Next review date**	
Assessor's name	Ben Halkon	**Assessor's description**	Staff	**Assessor's supervisor**	Teresa Vidal-Calleja
Location(s) of activity	Acoustic labs at UTS Tech Lab	**Lab Manager (or equivalent) of activity location (if relevant):**	Qiaoxi Zhu	**Planned activity date(s):**	Ongoing research project
Persons at risk	Workers / Students / Visitors	**Persons consulted** (consider anyone with access to or affected by the activity)	Qiaoxi Zhu		
Reference legislation, standards, codes of practice, manufacturer's guidance etc used to help identify hazards and control measures relevant to this activity *Refer to the H&S Policy, Codes of Practice, Australian Standards*					

Instructions: Use the guidance notes at the end of this document to help complete this table

TASK List and describe hazardous task/activity/process/step/equipment	**ASSOCIATED HAZARD(S)**	**INHERENT HARM** Harm that could occur from these hazards if controls fail or are not in place.	**EXISTING CONTROL MEASURES** Control measures currently in place to minimise risk	**RISK LEVEL** (H,M,L)	**PROPOSED CONTROL MEASURES** Additional control measures needed to reduce risk further	**TARGET DATE** To implement proposed controls	**RESIDUAL RISK LEVEL** (H,M,L)
Play sounds from loudspeakers	Loud/long duration noises	Too loud/long noise may affect hearing.	*Avoid playing sounds too loud/long; only play loud sounds if required when room is emptied of personnel.*	L			
Running audio/power cables on ground	Trip hazard & electrical hazard	Personnel tripping over lead on the floor. Electrical shorts/shocks from faulty lead.	*Ensure extension lead is placed so that it is not a trip hazard. Route cables away from areas of foot traffic. Limit no. of people in room at one time. Take care while moving around.*	L			

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TASK List and describe hazardous task/activity/process/step/equipment	ASSOCIATED HAZARD(S)	INHERENT HARM Harm that could occur from these hazards if controls fail or are not in place.	EXISTING CONTROL MEASURES Control measures currently in place to minimise risk	RISK LEVEL (H,M,L)	PROPOSED CONTROL MEASURES Additional control measures needed to reduce risk further	TARGET DATE To implement proposed controls	RESIDUAL RISK LEVEL (H,M,L)
Conduct experiments in confined rooms	Isolated in rooms	Be locked in an enclosed room	*Conduct experiments with another staff/student together.* *Implement isolation measures in the working space, such as using orange poles and signs, to mitigate potential risks associated with lab visitors and tours.*	M			
Using power extensions leads or boards	Connect many electrical components	High loads for power boards	*Avoid large power consumptions for each power board*	M			
Using the audio interfaces, loudspeakers and microphones	Potential damage & electrical hazard	Damage of the devices from improper usage. Electrocution from the devices.	*Connecting points and power cables are properly connected. Adhere to the manual instructions diligently. Exercise caution when handling the equipment, particularly the sensitive microphone and its cable. Prior to any adjustments to the software and/or hardware, obtain authorization from the academic supervisor and lab manager. Ensure all electrical items used are "tested and tagged"*	M			
Using steel frames, tripods and other support structures	Potential damage, risk of toppling/landing.	Potential damage to the net floor in the anechoic chamber or injury/damage to people/equipment	*Ensure the frame is placed gently on the net floor in the anechoic chamber. Do not overbalance frames with equipment without tying/strapping down or otherwise supporting.* *Where possible, opt for a microphone/loudspeaker stand with a round base (instead of a tripod) to protect the catch net in the anechoic chamber.*	M			
Movement in the anechoic chamber	Potential damage	Potential damage to the sound wedges in the anechoic chamber	*Ensure no touching and keep distance with the sound wedges.*	L			

TASK List and describe hazardous task/activity/process/step/equipment	ASSOCIATED HAZARD(S)	INHERENT HARM Harm that could occur from these hazards if controls fail or are not in place.	EXISTING CONTROL MEASURES Control measures currently in place to minimise risk	RISK LEVEL (H,M,L)	PROPOSED CONTROL MEASURES Additional control measures needed to reduce risk further	TARGET DATE To implement proposed controls	RESIDUAL RISK LEVEL (H,M,L)
Use of hand tools	Limited	N/a	*Use the right tools for the job.*	L			

Emergency preparation and response

EMERGENCY List and describe foreseeable potential emergency situations	INHERENT HARM Harm that could occur from these hazards if controls fail or are not in place.	EXISTING CONTROL MEASURES Control measures currently in place to minimise risk	RISK LEVEL (H,M,L)	PROPOSED CONTROL MEASURES Additional control measures needed to reduce risk further	TARGET DATE To implement proposed controls	RESIDUAL RISK LEVEL (H,M,L)
Be locked in an enclosed room	Isolated in rooms	*Conduct experiments with another staff/student together* Obtain a Duress tag from the security when working alone in an enclosed room. Keep in touch with colleagues regularly using teams/emails	L			
Injured while moving or lifting heavy objects	Personal injury/ medical emergency/ fatality	Seek first aid/medical assistance. Call 6 (from fixed line) / 0490 441 886 (from mobile) for security assistance. Report the incident in HIRO within 24 hours.	L			
Collision with building	Property damage	Preserve the scene and inform the facility supervisor. Call 6 (from fixed line) / 0490 441 886 (from mobile) for security assistance. Report the incident in HIRO within 24 hours.	L			
Electrical fire	Personal injury/ fatality	Make sure all electrical components are tested and tagged. Seek warden assistance to extinguish the fire with class E extinguisher, and if it is safe to do so. Call 6 (from fixed line) / 0490 441 886 (from mobile) for security assistance. Report the incident in HIRO within 24 hours.	L			

Sign-off and Approval

Assessor's Name:	Ben Halkon	Reasonably practicable control measures identified and implemented	Signature	[signature]	Date	11/07/2024
Lab Manager Name: (if relevant)	Qiaoxi Zhu	Have been consulted on the suitability of the space for the activity	Signature	Qiaoxi Zhu	Date	22/07/2024
Responsible supervisor's* Name:	Teresa Vidal-Calleja	Satisfied that control measures will reduce risk to an acceptable level	Signature	[signature]	Date	5/8/24

*Responsible supervisor is the person with control/authority over the activity.

Acknowledgement of Understanding

Persons performing the activity/tasks sign that they have read and understood the risk assessment.

Note: For activities which are low risk or include a large group of people (e.g. open days, BBQ's, student classes etc), only the persons undertaking the key activities should sign below. For all others involved, the information can be covered by other methods (for example a safety briefing, induction, and/or safety information sheet).

Student / Staff name	ID	Date	Signature	Remarks
John Wassermann, EPA	N/A	31/7/2024	[signature]	

Guidance notes for completing the risk assessment

TASK
Briefly describe hazardous tasks involved in this work activity – For example, Operating, Handling, Using … (Include names) of hazardous equipment, substances or materials used, and any quantities and concentrations of substance(s) or reaction products.

ASSOCIATED HAZARDS
Manual Handling – moving objects, repetitive movements, lifting awkwardly, lifting heavy objects
Work Environment – extremes in temperature, work at height, explosive atmosphere, slippery surfaces/trip hazards, work load, work alone, work after hours, confined spaces, infrastructure
People – potentially violent or volatile clients/interviewees, harassment, bullying, victimisation, poor culture
Environmental – emissions to atmosphere, discharge to soil and water bodies (including stormwater run-off), nuisance noise & odour, poor ventilation/air quality
Plant & Equipment – noise, vibration, dust, moving parts (crushing, friction, stab, cut, shear), pressure vessels, lifts/hoists/cranes, sharps, maintenance, design/assembly, AEV/Drone, hot work
Electrical – plug-in equipment used in 'hostile' work environment, exposed conductors, high voltage equipment
Chemical – hazardous substances, dangerous goods, fumes, dust, compressed gas, hazardous waste
Biological – exposure to bodily fluids/infectious materials, pathogenic microorganisms (bacteria, viruses, parasites, fungi), security sensitive biological agents, sharps/needles, animal bites and scratches, allergies to animal bedding, dander and fluids
GMOs – dealings with genetically modified organisms
Cytotoxins – carcinogens, mutagens or teratogens
Radiation (ionizing) – Ionizing radiation source such as radioactive substance or radionuclide, or irradiating apparatus
Radiation (non-ionizing) – including lasers, microwaves or UV light

INHERENT HARM
Provide details of the harm that could be caused to people or the environment if something goes wrong.
For example: inhalation of fumes, laceration, injury to back, infection, burns to skin or eyes.
Think about what could happen if controls fail or are not in place.

EXISTING CONTROL MEASURES
This is existing measures in place to reduce risk to an acceptable level. Apply the "Hierarchy of Controls", listed below, when deciding the best control measure to apply. Control types closer to the top of the list are preferable.

1. ELIMINATE THE HAZARD. For example, work from the ground with a long-handled tool instead of a ladder thus eliminating work at height.
2. SUBSITUTE THE HAZARD. For example, use a less dangerous piece of equipment or chemical.
3. ISOLATE THE HAZARD FROM PEOPLE. For example, move a noisy equipment into a room that is not accessed when it is in operation.
4. USE ENGINEERING CONTROLS. For example, use a fume cupboard for chemicals, use a guard for rotating parts.
5. USE ADMINISTRATIVE CONTROLS. For example, change work practices, provide training, use signage, develop a safe work method statement.
6. USE PERSONAL PROTECTIVE EQUIPMENT (PPE). For example, respirator, hearing protection, gloves. Training and information is required for the use of PPE.

PROPOSED CONTROL MEASURES
List control measures not currently in place but you plan to put in place before the activity starts.

RISK LEVEL (High / Medium / Low)
The level of risk can be determined by combining consequence and likelihood using the risk matrix below. Residual risk is the level with all control measures in place (existing and proposed). It should be reduced to a level acceptable by management.

CONSEQUENCE OF HARM - This is how bad it will be if something does go wrong e.g. the number of people that could be harmed, the severity of injury.

LIKELIHOOD OF HARM - Chance of harm occurring is affected by the duration of the activity and its frequency; the number of people doing the activity and the level of exposure to the hazard.

For more information on risk determination refer to the UTS Risk Management Procedure

Likelihood			Health & Safety Risk				
	The risk is expected to occur in most circumstances	Almost certain	Moderate	High	High	Critical	Critical
	The risk will probably occur in most circumstances	Likely	Moderate	Moderate	High	High	Critical
	The risk should occur at some time	Possible	Low	Moderate	Moderate	High	High
	The risk could occur at some time	Unlikely	Low	Low	Moderate	Moderate	High
	The risk may only occur in exceptional circumstances	Rare	Low	Low	Low	Moderate	Moderate
			Insignificant	Minor	Moderate	Major	Catastrophic
			Non-injury incident or first aid treatable injury only	Illness or injury that requires medical attention leading to 0 to 10 days off work but does not permanently impact health or wellbeing of an individual	Injury or ill health requiring medical attention leading to over 10 and up to 20 days off work but does not permanently impact health or wellbeing of an individual	Injury or ill health requiring hospital admission leading to over 20 days off work but does not permanently impact health or wellbeing of an individual	Single or multiple deaths or a serious injury that permanently impacts health and wellbeing of an individual
			Consequence				

Appendix D – II Noise Camera System Certificate of Compliance

INTELLIGENT INSTRUMENTS

Certificate of Conformance

Date of Issue: 10th April 2024
Customer: NSW EPA
Certificate Number: CONF438-1
Analyser: Intelligent Instruments SoundVue™, serial INM-438
Microphone: PCB Piezotronics Type 377B02, serial 00352176
Preamplifier: PCB Piezotronics Type 426E01, serial 00084754

This is to certify that the instrument was tested and calibrated at the Manufacturer's factory according to their specification and that the product satisfied all the requirements of the following standards:

IEC 61672-1:2013 Class 1

The instrument also received a functional check prior to dispatch in accordance with our standard procedures.

Intelligent Instruments recommends that the instrument is calibrated at an interval of 12 months from first installation.

Signed: .... Position: Director Date: 10th April 2024

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SO16 7DP, United Kingdom

Registered Number 12199999
Registered in England & Wales

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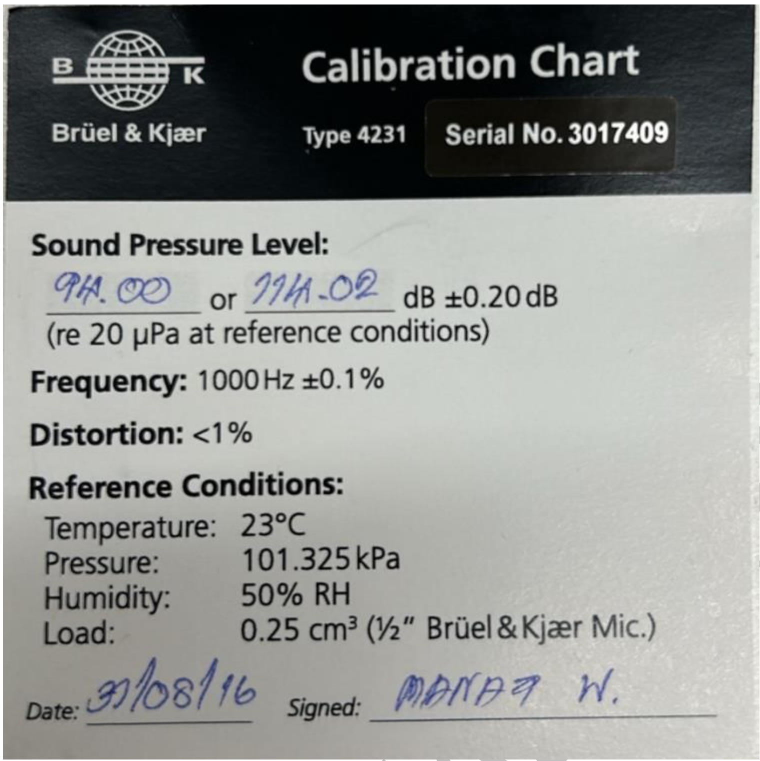
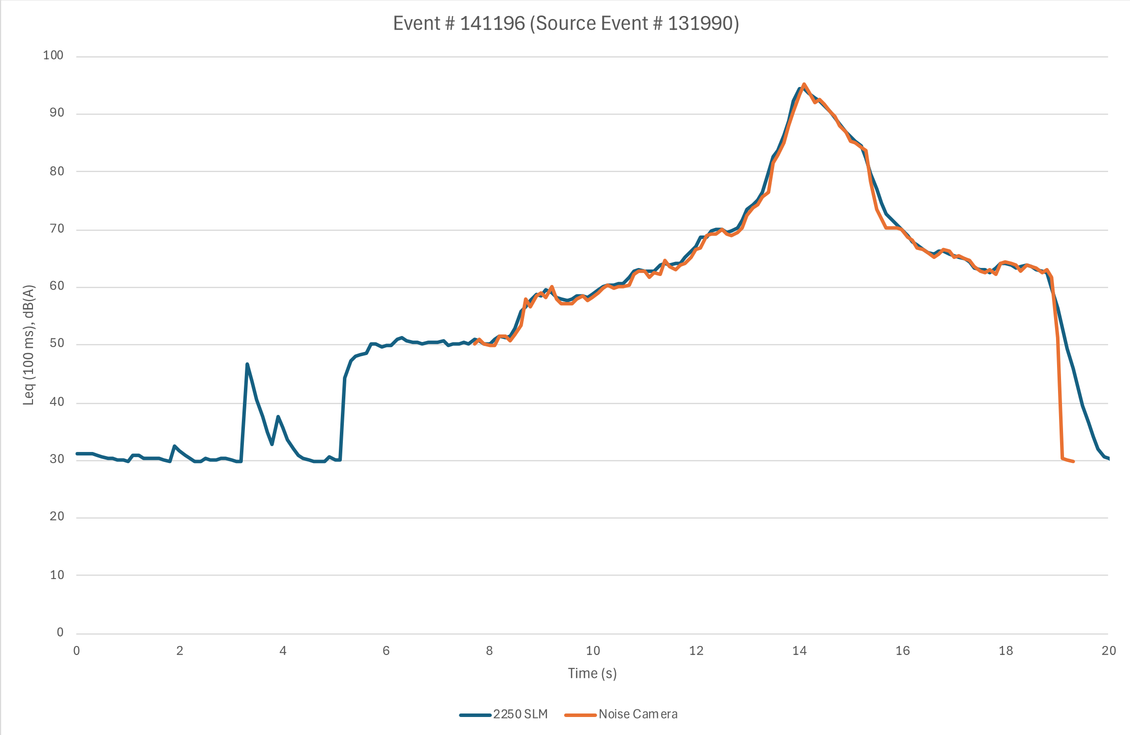
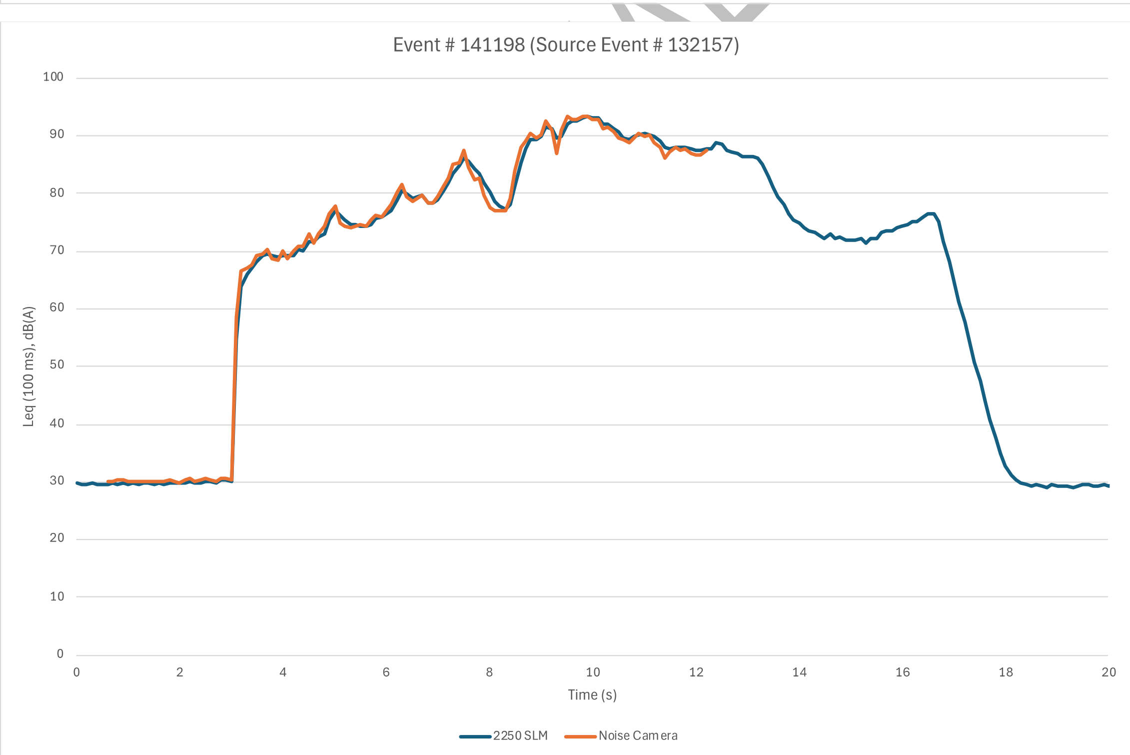
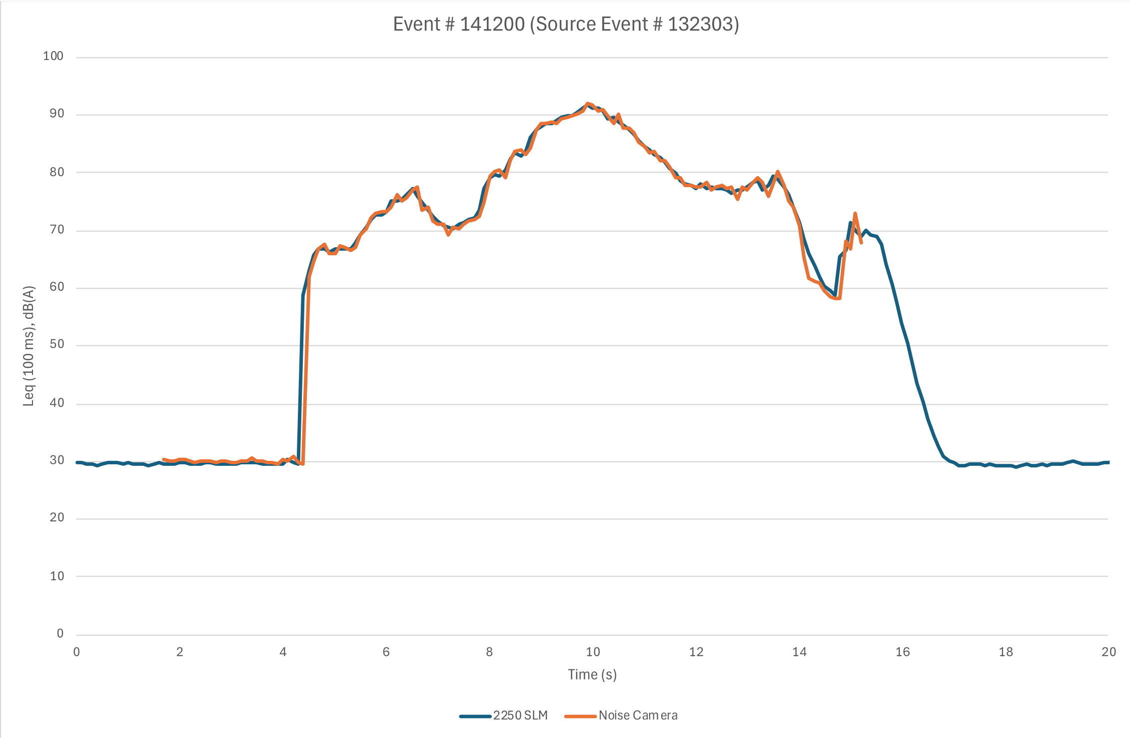
Appendix E – UTS B&K Type 4231 calibrator charts



Appendix F – Manually aligned data for Noise Camera vs. B&K Type 2250 SLM



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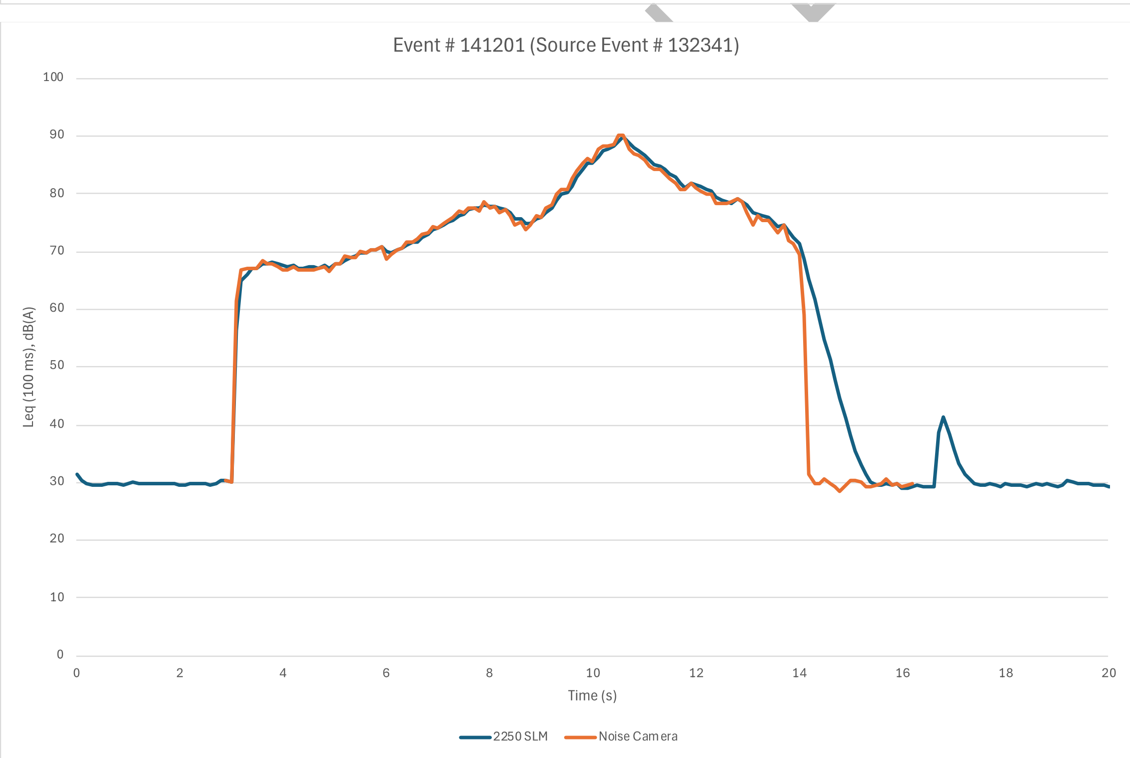
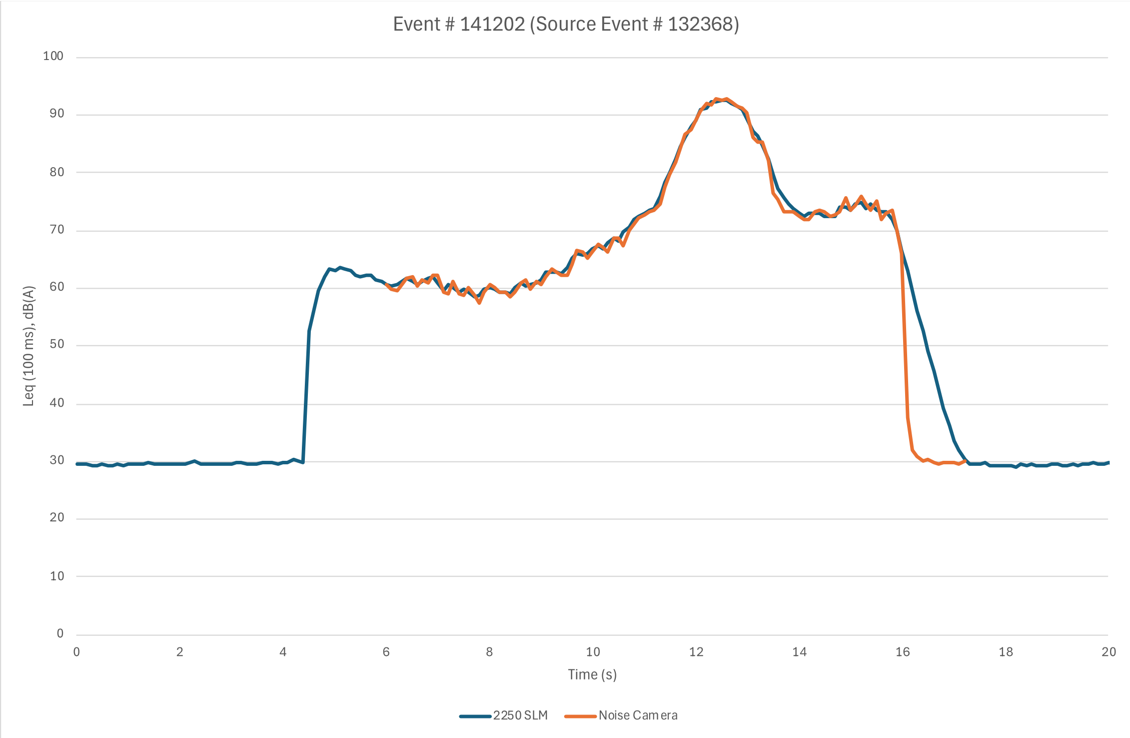
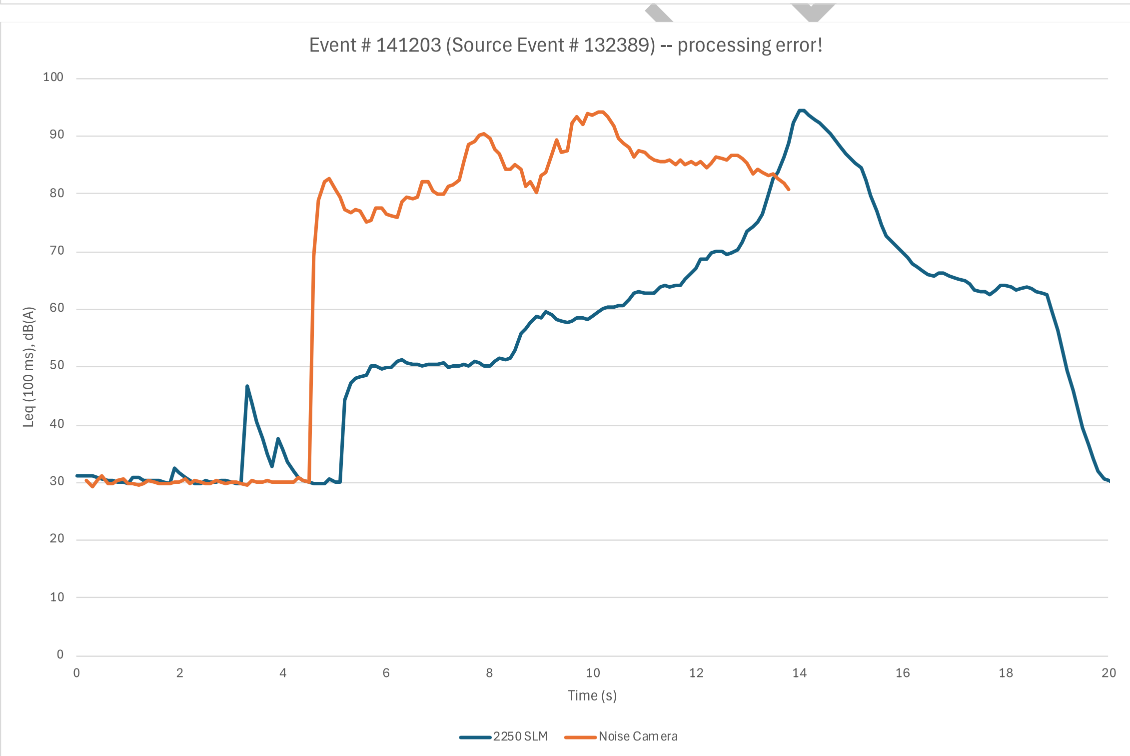
Leq (100 ms), dB(A)
Time (s)
2250 SLM
Noise Camera


Event # 141201 (Source Event # 132341)
Leq (100 ms), dB(A)
Time (s)
2250 SLM
Noise Camera


Event # 141202 (Source Event # 132368)
Leq (100 ms), dB(A)
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
Time (s)
2250 SLM
Noise Camera


Event # 141203 (Source Event # 132389) -- processing error!
Leq (100 ms), dB(A)
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
Time (s)
2250 SLM
Noise Camera