11TH INTERNATIONAL SYMPOSIUM FIELD MONITORING IN GEOMECHANICS

How to maximise value from noise and vibration monitoring: 4 key ways for environmental managers to get more from their data

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Abstract

We have seen a recent boom in the monitoring of noise and vibration on construction and infrastructure projects. Ambitious development schemes designed to unlock the (often substantial) value of confined urban sites, alongside major upgrades to infrastructure, means there are more and more heavy engineering works taking place in constrained urban locations. Such projects are permitted providing they adhere to, amongst other things, increasingly stringent environmental regulations and Best Practice commitments.

Noise and vibration monitoring is one method to measure project-related environmental impacts on the surrounding community. Monitoring data can demonstrate compliance with pre-agreed trigger levels and other environmental obligations. Taken a step further, real-time data can be used to manage works and control adverse effects before they occur. As projects face constant pressure to achieve high output during construction, with the right approach, noise and vibration management can provide added value that goes far beyond a basic audit trail of environmental compliance. The effective control of noise and vibration risks can play a key role in project success through maximising construction output in respect of regulatory, site and cost constraints.

That said, in a sector of financial fragility and slim profit margins, 'fulfilment of obligations' is often seen as 'unwanted project costs', which drives a do-minimum mindset. Carried out entirely as a tick-box exercise, noise and vibration monitoring is inadequate as a tool to track compliance, so you can forget any wider added value. Monitoring alone rarely provides a complete solution. It must be led by a proper understanding of project obligations and site-specific risks in order to define the correct level of approach.

Here are four ways to ensure you get the most out of monitoring and make it a valuable asset on your next project.

Keywords: Monitoring, Consultancy, Noise, Fit-for-purpose, Added Value.

1. Introduction

Noise and vibration control is quickly becoming an integral part of the success of construction and infrastructure projects, and the stakes are getting higher to ensure the right approach is chosen to respect the regulatory constraints without adding unwanted costs to the project.

Noise and vibration monitoring is the most commonly used method to measure a project's environmental effect on the community as it uses data collected on site and analysed (subsequently or in real time) to verify compliance with the relevant regulations. However, due to the multitude of parameters characterising construction and infrastructure projects, whether it is their locations, their size or the engineering works undertaken, a 'one-approach-fits-all' is unlikely to be satisfactory. Although it might be sufficient to tick the environmental compliance box, a more tailored solution would answer the project's needs and become an essential tool for its success.

In this paper, we will explore four ways to optimise noise and vibration control through implementing 'fit-for-purpose' monitoring solution, considering monitoring as part of a wider environmental management process, making good use of monitoring data and assessments to unlock wider benefits, and finally, showing how positive collaboration with an accomplished specialist will favour project interests.

2. Implement monitoring that is fit-for-purpose

The latest long-term acoustic monitoring equipment is designed to be user-friendly, including use by the non-expert. It comes with integrated data processing, real-time alerts and web analysis. If a project's monitoring requirements are well-defined (i.e., contains detailed monitoring locations; measurement parameters; trigger alarm levels; and so on), then off-the-shelf monitoring equipment is arguably smart enough to provide reliable and robust data without the guidance of an acoustic specialist. But, more often than not, monitoring requirements are ambiguous and it's down to the project team to define how they will go about it.

Unfortunately, there's no one-size-fits-all solution. For large or linear sites, a series of short-term attended monitoring surveys in relevant positions can be more appropriate than long-term monitoring in a fixed location. There may be complex noise restrictions which limit what work can be done and when. Work can be closely regulated, and specific contract requirements can trigger significant penalties or costly stoppages resulting from noise and vibration issues. A common mistake here is to install an excessive number of monitors and create an overwhelming amount of data which becomes impractical to interpret. Equally, there are less critical projects where work is located away from sensitive neighbouring communities and assets. Such projects may not even need monitoring at all, so why not push back on the requirement entirely?

It's not uncommon for a project to find out data is unusable at the exact time it's called upon (to address a complaint for instance). Even if monitoring is not routinely used for site management, incoming data must still be analysed regularly to ensure it's reasonable and reliable. There are many factors which could cause poor quality data, some being quite technical and difficult to spot. This is just one example of how monitoring can be unfit for purpose. Another is the demand for cheaper plug-and-play equipment such as all-in-one monitoring systems. Whilst integrated noise, vibration and dust stations can provide a quick and easy solution to monitoring, the inherent restriction of measuring everything in the same location is nearly always less than ideal and brings into question the validity of the data for environmental risk management.

In addition to poor quality data, some noise data may also be considered less suitable for the circumstances it is being used in. This is where the value of industry experts becomes apparent as they help identify suitable methodologies that will provide the most useful results. An example of this took place at one of our major projects recently where concerns were raised by a neighbouring animal rehoming centre about potential noisy works affecting resident dogs. Sixense was then able to carry out an analytical survey reflecting the specific noise frequencies to which dogs are more sensitive, helping provide a valuable case-specific conclusion.

Monitoring without fully understanding the need for it may result in a monitoring programme that is neither fit-for-purpose nor optimised to actively benefit the works for which it is intended. The best approach to monitoring should account for the risk of adverse impacts and understand how best to utilise the data to mitigate these impacts. Typically noise monitoring may be seen as a 'reactive' tool, providing retrospective information to which we can adjust future activities, in order to for instance, stay within acceptable or agreed noise limits.

A more 'proactive' approach to managing noise can be achieved for example through Artificial Intelligence (AI) via 'noise prediction'. The value of this became apparent on the Thames Tideway (East) project where Sixense in collaboration with CVB JV was able to develop software, *SmartNoise*, to assist the project team to actively manage works and stay within required noise limits. In practice, these constraints generally take the form of a "noise credit" imposed on the contractor: a maximum average noise level to be complied with over periods of time defined by law, the local authority and/or contractual conditions. *SmartNoise* solution uses ongoing measurements and calculations to provide a real-time forecast of when noise limits would be reached and for the contractor to manage their 'noise credit' at a glance. This allowed site activity types and locations to be strategically staggered to ensure works were not halted and can remain within noise limits.

Figure 1: Example of *SmartNoise* indicators dashboard

Noise and vibration risks arise from a combination of factors such as working methods, site-specific constraints, policies, and technical standards. Detecting and quantifying risk is not straightforward and requires both good knowledge of a project and good technical acoustic experience. Without these skills, risks will go unregistered and monitoring becomes an exercise to serve a general requirement rather than to accomplish any wider purpose such as proactive risk management.

3. Consider Monitoring as part of a wider environmental management process

Monitoring is just one aspect of an integrated management process and is far more valuable when used proactively as part of a wider strategy to anticipate risks and challenges before they arise (Figure 2). This involves understanding the project's environmental requirements and then, using an appropriate means of assessment, to maintain a register of key noise and vibration risks. The goal is to ensure the project is fully compliant whilst operating the most favourable works programme possible. The first step is to understand the contract requirements to identify any project-specific risks. Once the site inputs are available, forecasting and risk-assessment will highlight potential issues and mitigation needs all of which must be compliant with project requirements. During works, monitoring is carried out both for compliance reporting and proactive risk management.

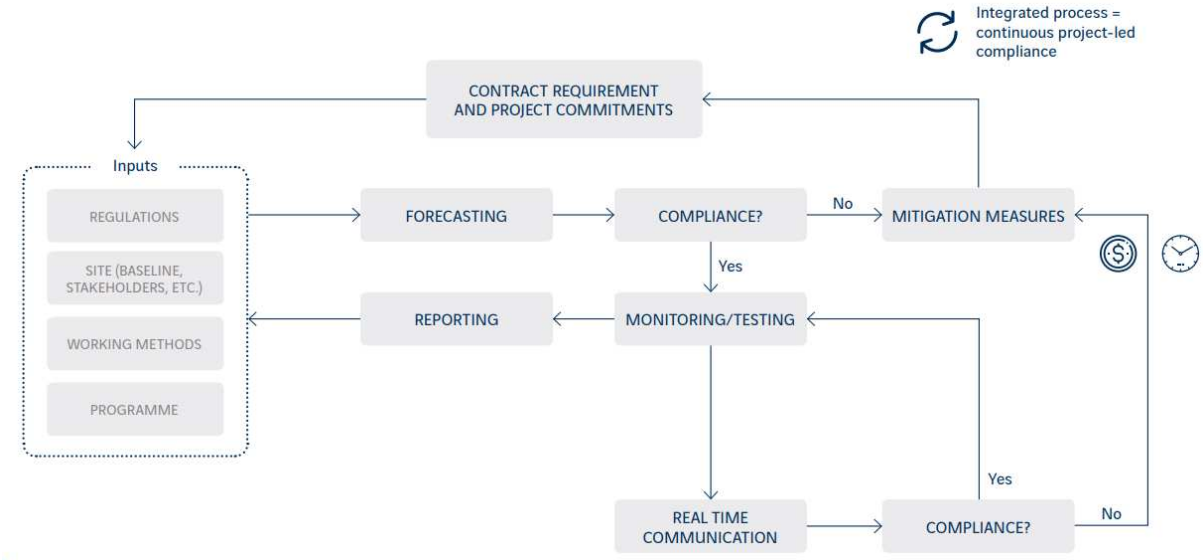

Figure 2: Integrated Noise and Vibration Risk Management Process

Forecasting relies on noise modelling using inputs such as the site working methods, the programme of works and the plant and equipment used for each site activity. Collaboration with the project team is invaluable to generate a realistic model, avoid over or under estimations of the noise generated on and assess any programme changes or optimizations needed. As an example, in collaboration with Align JV., responsible for the C1 segment of the HS2 project, a sound barrier assessment was carried out to determine the type and dimensions needed at the site-boundary to remain within required noise limits. This helped ensure compliance through noise modelling, removing the need for potential additional mitigations once the works were ongoing.

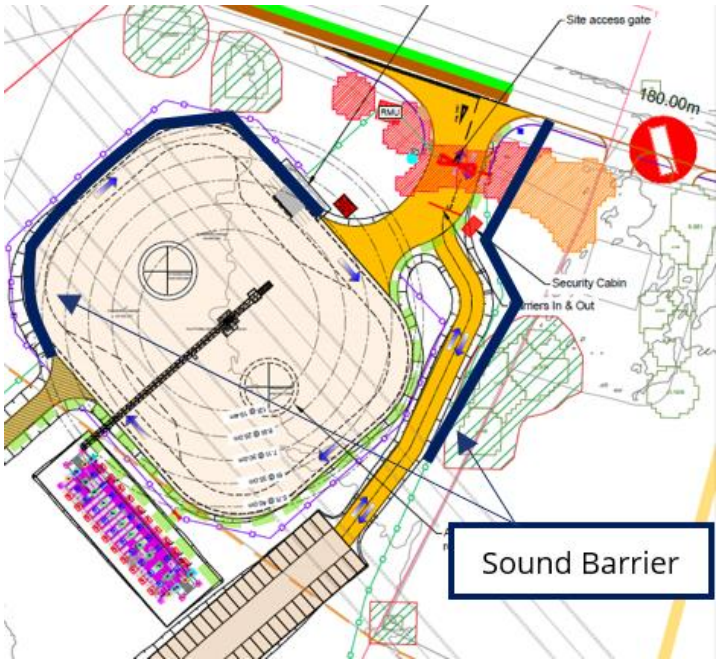

Figure 3: Sound barrier modelled for a construction site

Best Practical Means (BPM) checks are another tool used to ensure compliance while being proactive and avoiding exceedances that can lead to delays. For HS2-C1 sites, once the BPMs are identified and agreed upon for each phase of works, checks are conducted monthly to confirm BPMs are in place and/or the need for any adjustments. This is then communicated to the sites and used to rectify any issue before they become a non-compliance.

BPM Site Checklist – Noise & Vibration			
General Observations	**Observed**	**In Place**	**Comment (providing details where BPM has/has not been employed and include photo evidence)**
Aural inspection of noise generating activities (include perception of the dominant noise sources).			
Reversing alarms – Are reversing alarms broadband in nature?			
Noise Barriers – Are temporary screens/barriers being used around static plant? Are the screens being used in good order, free from gaps/holes?			
Plant Items – Is there evidence of any plant on-site which is not listed in the consented plant list?			
Plant/Equipment Use – Are plant being used in correct manner? Engines covers should be closed, engines to be shut down when not in use. Are engines being over-revved? Are drop heights acceptable during loading operations?			
Are doors to enclosures kept closed?			
Are vibration generating plant in use on site? Hydraulic Breakers, Vibratory rollers, Whacker plates etc. Could alternative plant be used for activity. e.g. Pulveriser instead of breaker?			
Is vibration noticeable at site boundary? Is it continuous/intermittent?			
Site Specific BPM Measures (obtained from S61 review)	**Observed**	**In Place**	**Comment (providing details where BPM has not been employed and include photo evidence)**
E.g. generators on site positioned as far away from sensitive receptors as possible			

Figure 4: Example of a BPM checklist

4. Make good use of monitoring data and assessments to unlock wider benefits

Successful noise and vibration management is about implementing a system that facilitates project-led decisions to achieve high environmental performance and, in parallel, maximise what can be achieved within the boundaries of regulatory, site and cost constraints. For instance, if non-compliance is picked up at the monitoring stage (as opposed to the planning stage), costly delays can be incurred until suitable mitigation measures are in place. The goal of the system is to maintain risk control and reduce the likelihood of an unexpected and costly stoppage. Figure 5 shows how the fundamental risk management process (shown in Figure 2) can be enhanced to unlock wider benefits for the project.

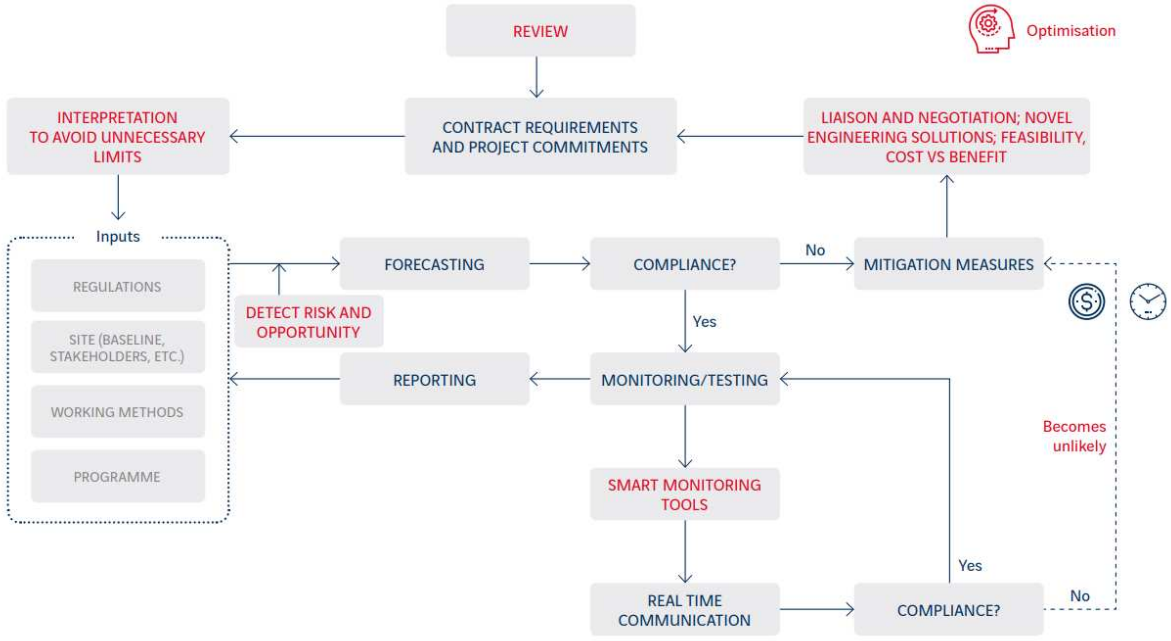

Figure 5: Adding Value to the Noise and Vibration Risk Management Process

Avoiding extra restrictions and easing existing ones is where effective monitoring and management can bring real value to a construction project. When engineering needs arose on HS2-C1 sites to extend the length of operation beyond allowable working hours, monitoring data was used to forecast and communicate the likely impact of the change(s) to the regulators to obtain permission for an extension to working hours. Without taking this proactive approach to anticipate noise issues, the associated delays could have been detrimental to the project. Regulators recognise the community benefits of well-managed sites and self-policing procedures. Transparency and sharing data upstream with stakeholders, neighbours, and regulators (i.e., in advance of complaints) will help gain trust - often a key step towards easing restrictions. Through constructive engagement with regulators, a project can negotiate justifiable opportunities to extend or intensify working times or practices by demonstrating risks are mitigated and closely managed.

In addition**,** monitoring provides an important feedback loop to aid more informed assessments and actions as the project progresses. Lessons learnt from interpreting attended and unattended monitoring data can be used to adapt working methods or enhance mitigation performance (Best Practicable Means) as previously explained. Knowledge gained from regular attended surveys often provides a useful context to assist with exceedance investigations. This form of feedback is becoming increasingly important with the emergence of IoT (Internet of Things), and other new technologies designed to unlock productivity growth in construction. Sixense have already developed smarter ways to manage and interpret data for rapid decision-making such as auto-categorisation of noise sources using machine learning.

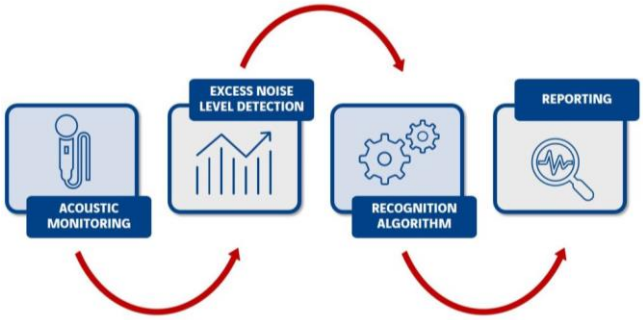

Figure 6: Novia innovative principle of operation using machine listening

Innovative technologies such as *Novia* & *SmartNoise by Sixense,* optimise construction methods, programme and on-site working practices for our clients, whilst also ensuring conformance with all legal, contractual, regulatory, and budgetary commitments. These solutions overcome the idea that environmental obligations are restrictive to construction. Instead, these 'smart tools' - in the hands of project focussed acousticians – are used to manage environmental risk, avoid costly stoppages, and unlock high added-value opportunities in terms of efficiency improvements and cost savings.

5. Positive collaboration with an accomplished specialist will favour project interests

Often to keep costs down, the role of an external specialist is removed or limited to what may be considered as 'essential services' such as on-going compliance assurances and the resolution of any problems if they arise. Working from a peripheral position on a project, the specialist is unable to maintain a good level of project understanding. They will be restricted in terms of the proactive technical advice they can provide to anticipate risks and unlock favourable opportunities. Emphasis is therefore shifted to the contractor (rather than the specialist) to judge when technical input is needed, which can lead to confusion over the role of a technical specialist and raise serious questions over responsibility for issues. The specialist can find themselves prevented from giving the level of technical input they feel is needed and would typically be expected. This outcome does not serve in the interest of anyone. Not only does it take longer for a specialist to get up to speed if called upon, but the project also misses out on the real value of having an expert involved - to ease restrictions; anticipate potential issues; provide practical solutions; and avoid costly delays.

Fees aside, another reason why a project may not wish to instruct the services of an acoustic specialist is because, at face value, noise and vibration management can seem restrictive. An alert message to stop work, or expert advice to build a noise barrier is never good news for programme or budget. A key role of a specialist is therefore pragmatism. A good external specialist will see the project's point of view when it comes to technical challenges in order to give advice that is both reasonable and practicable, and to advise when all reasonable steps have been exhausted. They will avoid giving a "no-go" answer, leaving the project in a difficult position. But to do this, the specialist must be in tune with the project to gauge the specific needs that will keep it on track. The specialist therefore needs to be experienced in the sector and must be responsive to the quickly changing needs of complex engineering schemes.

Frictionless sharing of relevant information between project teams and the noise and vibration specialist is vital for the risk management process to work effectively. One way to facilitate information flow and retain focus on project needs is to integrate the acoustic specialist within the project team. Positive collaboration on this level is, however, often restricted by the way in which the acoustic consultant is engaged. Construction projects always have tight budgets and therefore demand cost certainty from the supply chain. Cost control typically means procurement on a lump sum basis. But unfortunately, there's nearly always a lack of understanding of what services need to be purchased because noise and vibration risks have not been looked at to any level of detail at procurement stage (often because design work is still ongoing). Without a defined scope at project kick-off, additional items inevitably mount up. Managing such a large amount of change is admin heavy and makes the relationship with the acoustic consultant increasingly contractual, which inevitably gets in the way of effective team working.

6. Conclusion

Many construction and infrastructure projects that spend large sums of money on noise and vibration monitoring are missing out on the benefits of having it due to a lack of appreciation of the project-specific risks and a drive for cost savings. Despite the helpful real-time functionality of today's smart monitoring equipment, there remains a widespread basic application of acoustic monitoring simply to fulfil an obligation. This monitoring-as-an-insurance approach has created a perception for many that noise and vibration management is of limited value, which is forcing a race to the bottom. However, it is often the case that more beneficial solutions can be found when monitoring is guided by project-specific needs. Projects should seek to detect noise and vibration risks at an early stage and throughout the project as part of a distinct system of noise and vibration risk management. To do this effectively, it is often necessary to work with an accomplished acoustic specialist who has a strong understanding of construction engineering. The role of the specialist is to guide the project through the cycle and seek to optimise each stage so that noise and vibration risk management is a valuable asset for the project. The specialist must therefore be incorporated to some extent into the project's day-to-day operations. When approached in this way, noise and vibration risk management will ensure projects remain in control of commitments and obligations, prevent costly unexpected stoppages, ease existing constraints, and unlock significant opportunities to become an extremely worthwhile project investment.

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