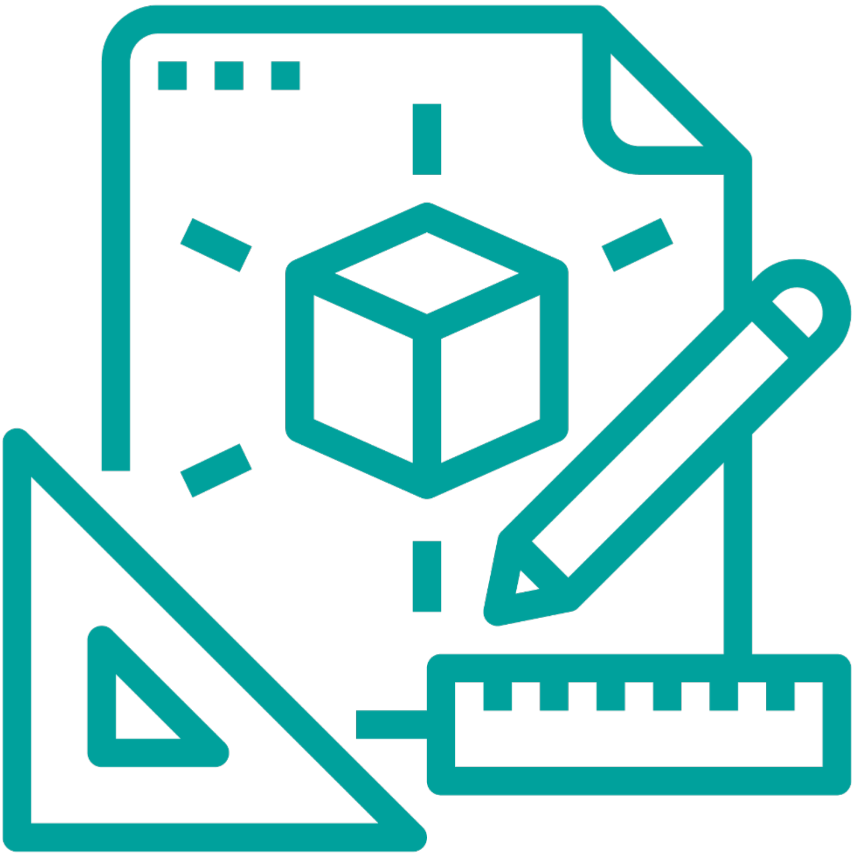
Operational Network of Air quality Impact Resources

Best Practice Guide

BP209 | Develop

Sensing device deployment planning: high-level design



Introduction

To establish a smart sensing network, a deployment planning process is required to establish where to locate devices, how to mount and install them, and how to secure approvals.

There are two stages to this sensing device deployment planning: high-level design, and detailed design (see Table 1). This OPENAIR Best Practice Guide chapter covers the ***high-level design*** process, which includes discussion of general plans and strategies for establishment of a sensing device network.

*Table 1. Overview of **high-level design** and **detailed design** of sensing device deployment planning*

High-level design (The focus of this chapter)	**Detailed design** (Not covered in this chapter)
This chapter addresses the following *high-level* design topics: • General deployment locations • General mounting infrastructure • Power supply strategy • General mounting solution(s) • Access and permission planning.	This chapter does *not* address the following *detailed* design topics: • Planning detailed deployment options • Documenting detailed deployment options for approval • Securing approvals • Labelling devices. **Please refer to the OPENAIR Best Practice Guide chapter *Sensing device deployment planning: detailed design* for guidance on these topics.**

Who is this resource for?

This resource is intended to assist local government staff (and contractors) who are tasked with the practical delivery of an air quality monitoring project.

How to use this resource

This Best Practice Guide chapter introduces key steps in high-level deployment planning for a sensing device network.

Once you have read this chapter, the **OPENAIR Best Practice Guide chapter *Sensing device deployment planning: detailed design*** can be used to guide more detailed planning.

You will then be ready to complete the **OPENAIR supplementary resource *Sensing device deployment planning: high-level design template***, using information specific to your own project.

High-level deployment planning and design should only begin *after* a clear ***data use case*** and ***business case*** have been established for your project. Refer to the **OPENAIR supplementary resource *Identify template*** for detailed guidance on developing these.

High-level design should be undertaken in parallel with technology procurement decision-making, because the context in which devices are deployed will heavily influence the technologies that you choose to procure.

The high-level design process

The high-level design process involves the investigation of a general location (or locations), and consideration of the practical options for device deployment in those locations.

This process[1] should consider all the factors described in Figure 1.

Assessing the suitability of general deployment locations
Aim: Identify one or more areas of interest on a map where you plan to deploy sensing devices. It is not necessary to specify precise locations at this time.

General mounting infrastructure
Aim: Identify one or more general kinds of mounting infrastructure within a general deployment location.

Power supply strategy
Aim: Develop a high-level plan for power supply at each general location. This need not be specific to individual mounting assets at this time.

General mounting solution(s)
Aim: Identify general mounting solutions that are appropriate for attaching chosen sensing devices to the mounting infrastructure options. Make a plan for their delivery, in line with project schedule and budget.

Access and permission planning
Aim: Identify access requirements for prospective deployment locations and mounting infrastructure options, and seek to minimise the complexity and cost of access where possible (through informed design choices).

Figure 1. Factors to consider when planning the deployment of your sensing devices

[1] These considerations are interdependent. The suitability of a general deployment location is determined, in part, by the presence of appropriate mounting infrastructure. The suitability of mounting infrastructure is, in turn, determined by its support for power supply, device mounting solutions, and general accessibility.

Assessing the suitability of general deployment locations

***Aim*: Identify one or more areas of interest on a map where you plan to deploy sensing devices. It is not necessary to specify precise locations at this time.**

General locations suitable for the deployment of sensing devices can be identified through a combination of three factors.

1. The general deployment location must serve the data use case

Data gathered in the location should relate to pollution creation and dispersal, or to pollution exposure.

- For data on **pollution creation and dispersal**, sensing devices should be located in a place that helps improve understanding of the creation and dispersal of air pollution at (and around) a pollution source.
- For data on **pollution exposure**, sensing devices should be located in a place that helps improve understanding of the exposure of a chosen group to pollution in a given location.

2. The general deployment location must have viable communications coverage

Sensing devices deployed within the general area of interest must have a reasonable chance of reliable connectivity with a communications network.

TIP: At this stage in the design process, it is a good idea to acquire a detailed communications coverage map for your local government area. If you are engaging a communications contractor (either for installation of a local area network, or for telecoms access), they should be able to assist you in accessing this kind of map.

Note: a high-level check of communications coverage for an area does not confirm that specific deployment sites within that area will have coverage. At this stage, you simply need a general indication that reliable connectivity can be achieved across the area of interest. More complex, on-the-ground communications checks will be required on a site-by-site basis, as part of detailed planning.

3. The general deployment location must have appropriate mounting infrastructure

You must have a clear idea of the available mounting infrastructure you intend to use in a general location (and whether it is appropriate for your project's purposes).

General mounting infrastructure

***Aim*: Identify one or more general kinds of mounting infrastructure within a general deployment location.**

'Mounting infrastructure' refers to physical assets onto which sensing devices can be mounted. A variety of types, materials, and ownership scenarios can apply (see Table 2).

Table 2. An overview of common mounting infrastructure options

Type	Material	Owner
Poles: • Smart poles • Power poles • Precinct lighting (small) • Street lighting (large) • Signposts • Other infrastructure supports (e.g. shade cloths, traffic lights, etc.) Other: • Bus shelters • Buildings/rooftops • Trees	• Steel • Concrete • Wood	• Local government • State government (e.g. transport authority) • Private organisation (e.g. developer) • Private individual (e.g. resident)

TIP: FAVOUR MOUNTING INFRASTRUCTURE THAT YOUR ORGANISATION OWNS

Mounting infrastructure owned by your organisation should be a preferred option for device deployment. This ensures that the process is:

- **simple** – administration and management are easier, both for installation and across the operational lifetime of the deployment
- **quick** – the approvals and installation process can be streamlined
- **affordable –** the deployment can be managed internally (e.g. by local government street infrastructure/maintenance staff), rather than needing to rely on external contractors; this leads to considerable installation/maintenance cost savings
- **flexible** – more flexibility is allowed, in terms of what is attached to the infrastructure, and mounting methods.

NOTE: It is possible to deploy devices on mounting infrastructure owned by third parties (e.g. power poles owned by an energy utility). While this may present additional constraints, it may be the only viable option for certain locations.

Assessing the suitability of mounting infrastructure

A general deployment location is likely to contain many different mounting infrastructure options. Aim to visit the area, and directly assess these options. Table 3 describes some assessment criteria that can be used to guide this activity.

Table 3. Criteria used to assess the suitability of potential mounting infrastructure

Questions to consider	Actions for you to take
Is it methodologically appropriate?	Confirm that the design of the mounting infrastructure being considered can meet the methodological requirements for correct installation of a sensing device, in line with a chosen data use case. For example: • Can the desired height above ground be achieved? • Would devices be exposed to significant thermal mass associated with the mounting infrastructure itself (and are there ways around this)?
Is it practically appropriate?	Confirm that the design of the mounting infrastructure being considered can meet the basic practical requirements for installation and operation of a sensing device. For example: • Can devices be installed in such a way as to keep them safe from vandalism, tampering, and theft? • Is there a viable power supply (e.g. mains power)? • Is a structurally secure mounting solution possible?
Is it physically and safely accessible?	Confirm that the general positioning of the mounting infrastructure being considered allows project staff and/or contractors to safely access it. It should be: • Directly physically accessible (e.g. this might rule out various private premises) • Safely accessible (e.g. this might rule out the median strip of a motorway).

TIP: CHOOSE REPEATING INFRASTRUCTURE

Repeating infrastructure has a single blueprint repeated many times through the urban environment (e.g. street poles, bus stops, and parking metres). Benefits include:

- **Simplicity**: a single mounting solution can work for multiple deployments
- **Efficiency:** the approvals and installation process can be streamlined
- **Affordability**: keeping costs to a minimum.

Power supply strategy

***Aim*: Develop a high-level plan for power supply at each general location. This need not be specific to individual mounting assets at this time.**

A smart device needs a power supply. The ability to deliver power to a device can be directly impacted by the choice of location and mounting infrastructure. When making high-level deployment design decisions for a device network, power supply should be a key consideration that informs the choice of mounting infrastructure *and* hardware procurement.

There are **three possible power supply options** for a smart sensing device (see Figure 2). Each option involves particular considerations that are relevant to the high-level design of a sensing device network (including the choice of general location, and general mounting infrastructure options).

Power Supply	Considerations
Battery-only	• Battery replacement
Solar + battery	• Solar exposure • Solar panel maintenance • Structural security • Aesthetics
Mains power	• Availability of mains power • Installation • Service provision

Figure 2. The three possible power supply options for a smart sensing device (and related considerations)

Battery-only power supply

Battery-only power supply is usually limited to small temperature and humidity sensing devices like this one. Almost all air quality sensing devices require solar or mains power. Image source: Lake Macquarie City Council

Table 4. Considerations for battery-only power supply: battery replacement

Consideration	Battery replacement
Description	If the planned operational period of a sensing network is greater than the estimated lifetime of batteries in devices, then a plan must be made for battery replacement. This requires access (with implications for approvals and safety), and carries additional costs.
Hypothetical example(s)	A network of devices requires all batteries to be replaced after two years. A range of mounting infrastructure options are available, including local government-owned street poles and utility-owned power poles. While deployment of devices on utility power poles can be negotiated, the utility company requires all installation and maintenance work to be carried out by high voltage certified electrical contractors, at considerable expense. The project budget can cover this cost for initial installation, but not for battery replacement. Therefore, a decision is made during high-level network design to avoid utility power poles.
Strategy	Aim to optimise power use by devices to extend battery life (so that it exceeds the planned operational period for the sensing network, avoiding the need for battery replacement). This can be done by altering device settings for data reporting and communications. If battery replacement cannot be avoided, select a general location that has easily accessible mounting infrastructure. Choose a type of mounting infrastructure that can be accessed using preferred contractors, within the planned operational budget.

Solar + battery power supply

A general location with a lot of trees may present limited options for device deployment (due to shading). Panels deployed near trees also tend to require more regular maintenance (due to fouling). Image source: Tweed Shire Council

Table 5. Considerations for solar + battery power supply: solar exposure

Consideration	Solar exposure
Description	Solar panels must receive enough sunlight to meet the power demand of a device, which is a major consideration for deployment locations.
Hypothetical example(s)	A lack of direct sun may rule out certain general locations (such as inner-city precincts with high-rise buildings). A review of local government-owned street poles in a particular area might conclude that most are in shaded locations, presenting limited options for device deployment.
Strategy	When selecting general locations and mounting infrastructure options for solar-powered devices, consider the range of deployment locations available that have viable solar exposure. Will there be enough viable locations to support the total number of sensing devices that you wish to deploy? Are the viable locations in places that support your data use case?

Table 6. Considerations for solar + battery power supply: solar panel maintenance

Consideration	Solar panel maintenance
Description	Solar panels can require regular maintenance to ensure that they are clean and functioning optimally. Even minor loss of effective panel surface area can result in loss of power to a device. Maintenance requires access, and is more likely to be needed regularly in some locations (and not others), making this a consideration for mounting infrastructure options.
Hypothetical example(s)	Mounting infrastructure in hard-to-access locations (e.g. a median strip on a highway) requires a more complex approval process for device maintenance, and potentially greater and more costly disruptions each time (e.g. road closures). Mounting infrastructure positioned near to overhanging trees is more susceptible to fouling from leaves and bird droppings, requiring more frequent maintenance.
Strategy	Consider the accessibility of the mounting infrastructure options selected, and avoid options where maintenance will be overly difficult to arrange, or costly to deliver. Unless a data use case requires monitoring near or underneath trees, it is best to avoid mounting infrastructure in these locations. If monitoring *does* need to occur near trees, ensure that the cost and administration of additional maintenance is in your budget.

Table 7. Considerations for solar + battery power supply: structural security

Consideration	Structural security
Description	A solar panel must supply enough power to meet the demand of a device. Its ability to do this is dependent upon the amount of solar exposure at a given site and the size of the panel. If solar exposure is limited, then panel size must increase to compensate. A larger panel weighs more and has greater wind loading, presenting structural security considerations that impact the options for mounting infrastructure.
Hypothetical example(s)	Several solar-powered devices are to be deployed across a town centre. Due to a nearby hillside, direct solar exposure is limited across the entire area. To compensate, a larger solar panel is required for all devices. The more robust engineering requirements for mounting this larger panel rule out the use of smaller precinct lighting poles as a viable mounting infrastructure option. The choice of possible mounting infrastructure options is therefore quite limited.

Strategy	Consider the solar panel specifications needed for a prospective general location and the amount of sunlight likely to be available at that location. Investigate engineering requirements for larger panels as early as possible. Ensure that time (for design and approval) and cost are factored into the project plan. With a prospective device vendor, explore the possibility of retrofitting a mains power option for some (or all) devices. In a constrained scenario, this may allow a larger number of possible mounting infrastructure options to be accessed.

Public precincts where there is an emphasis on design and aesthetics can restrict the use of large solar panels on aesthetic grounds.

Table 8. Considerations for solar + battery power supply: aesthetics

Consideration	Aesthetics
Description	As described above (see structural security), certain deployment contexts can require a larger solar panel to support reliable device operations. This carries implications for the overall aesthetics of the installation, which can be a concern in public precincts.
Hypothetical example(s)	A newly redeveloped retail precinct has been fitted with smart poles, which significantly reduce pole clutter, and form part of an overall clean aesthetic for the area. Due to its aspect, the area receives a lot of building shadow. Any solar-powered device would require a larger-than-standard panel to support it. The local government team in charge of place-making opposes the installation of such large panels on the new smart poles. Therefore, solar power is ruled out for that general location. The only recourse would be to adapt devices to use mains power.
Strategy	If devices are to be deployed in public precincts where aesthetic considerations *might* be a concern, reach out to the relevant team (e.g. local government place-making) early in the high-level design process, to establish any constraints on decision-making. With a prospective device vendor, investigate the possibility of retrofitting the devices with a mains-powered option.

Mains power supply

Table 9. Considerations for mains power supply: availability of mains power

Consideration	Availability of mains power
Description	If a device requires mains power to function, then mains power must be available within the prospective mounting infrastructure *or* be extendable from a nearby source. Availability includes physical presence of a power supply, reliability of that power supply, and the ability to secure access to it. Limited availability of mains power can significantly limit potential mounting infrastructure options for mains-powered devices.
Hypothetical example(s)	a) A mains-powered device is an ideal fit for a project. However, the need for mains power essentially rules out the possibility of deploying these devices in a number of general locations of high interest. In locations where these devices can be deployed, there are only limited options for mounting infrastructure with available power. b) A mains-powered device is to be deployed on a sports field, and lighting poles have been identified as a potential type of mounting infrastructure. However, power supply to the lighting poles is not reliably maintained 24 hours a day, and is only available during the evening. This rules out deployment on lighting poles, unless a hybrid mains/battery system is installed.
Strategy	If a device requires mains power, there will always be a limitation on the range of deployment locations, and types of mounting infrastructure that can be used. Workarounds include: • Retrofit a mains-powered device with a solar/battery system. Note: this can potentially cost more than the device itself, and can be bulky and unsightly, which may raise aesthetic concerns for deployments in public precincts. • Retrofit a battery system to compensate for intermittent mains power supply. The battery charges when power is available, and discharges when it is not available, allowing a device to remain permanently online.

Table 10. Considerations for mains power supply: installation

Consideration	Installation
Description	In most cases, a mains-powered device must be connected to a mains power source by an electrical contractor. This can significantly raise the cost of per-device installation. However, the complexity of establishing a new mains power connection in a given location can vary, depending on proximity to a suitable power supply. This means that the choice of mounting infrastructure has a bearing on the cost of device installation. Furthermore, the approval process for connection is likely to extend the timeline of the overall approval process for device deployment, potentially impacting project delivery.
Hypothetical example(s)	A local government is exploring air quality at a sports precinct. Two mounting infrastructure options are available to support a network of mains-powered devices: 1. local government-owned smart poles through pedestrian areas, which already contain general power outlets 2. lighting poles with high voltage power, located within stadiums that are managed by state government. Installation of a device on (1) is simple, relatively low-cost, and can be managed internally. Installation of a device on (2) requires a costly extension and conversion of an existing power supply, and a complex approval process. As a result, option (1) is favoured and option (2) is discounted, ensuring that installation costs remain within budget, and devices are deployed within the project timeline.
Strategy	When selecting mounting infrastructure with mains power supply, consider the following: • **The physical accessibility of existing mains infrastructure**: does it require extending? Are there existing outlets, or will an outlet need to be installed? • **Power supply voltage**: this may not be the same as the voltage required by the sensing device, requiring a transformer to be installed at additional cost. • **Power intermittency**: will a battery need to be installed to compensate?

Table 11. Considerations for mains power supply: service provision

Consideration	Service provision
Description	Mains power is provided as a service by a utility company, or by a third-party intermediary (e.g. the owner of the mounting infrastructure). Depending on the choice of mounting infrastructure, there may be a per-device connectivity fee, or this may be waived.
Hypothetical example(s)	A local government is working with a community group to establish a network of particulate sensing devices that require mains power supply. Two mounting infrastructure options with mains power are under consideration: • Local government-owned precinct lighting poles • Precinct lighting poles owned and managed by a shopping centre. If devices are connected to local government-owned poles, they can access power at no cost to the project. However, the shopping centre has indicated that they would charge a recurring annual fee for power supply. A decision is made to only use local government-owned poles, avoiding recurring fees that would prove to be unsustainable for the community group to pay over the long term.
Strategy	Be clear about the capacity of a project or initiative to cover recurring annual service costs. Speak with mounting infrastructure owners early to understand power supply arrangements, and to avoid recurring costs where they do not align with project requirements.

General mounting solution(s)

***Aim*: Identify general mounting solutions that are appropriate for attaching chosen sensing devices to the mounting infrastructure options. Make a plan for their delivery, in line with project schedule and budget.**

A 'mounting solution' refers to the combination of brackets and fixings used to attach a device (and associated equipment, such as a solar panel) to a piece of mounting infrastructure. Most commercially available sensing devices come with out-of-the-box mounting solutions, however these may or may not be appropriate for a particular mounting infrastructure option (see Table 12).

In cases where out-of-the-box mounting solutions are inappropriate, a custom mounting solution is required (see Table 13).

Table 12. Three main mounting solution options

Mounting solution option	Considerations
A standard 'out-of-the-box' mounting solution	This is the simplest and most affordable option. However, it is likely to be limited to a narrow set of deployment options. Check the maximum pole diameter it can be mounted on, and whether it can be deployed using screws, clamps, or straps.
A custom solution (using standard materials)	A custom mounting solution may be achieved using pre-existing materials. The additional costs for this should be minimal.
A custom solution (using custom-designed components)	A custom solution may require development of entirely new custom-designed components. The time and cost for design, approval, and fabrication of a custom-designed mounting solution can be significant.

Table 13. Common custom mounting solutions

Custom mounting solution	Description	Approach
Pole extension mast	Extends the height of an existing pole to achieve the desired deployment height (e.g. 3.5m)	**Custom solution using standard materials** (achievable with standard poles, bolts, welding equipment, etc.)
Custom smart pole connector	Connects to outer channel of a smart pole on one end, and a sensing device on the other end	**Custom-designed component** (connects between standard smart pole components, and standard device bracket)
Custom bracket that allows screwing into a wooden pole	Most standard brackets connect to a pole using steel straps (to screw into wood, a connector plate with holes is required)	**Custom-designed component** (a connector plate that can be added to the standard device bracket)

Access planning

***Aim*: Identify access requirements for prospective deployment locations and mounting infrastructure options. Seek to minimise the complexity and cost of access where possible, through informed design choices.**

Access refers to the ability to enter an area to engage in planned activities, or to directly engage with a piece of infrastructure (for the purpose of installing or maintaining hardware that is mounted on it). The complexity and cost of access varies according to the choice of general location and mounting infrastructure. Access planning is therefore a key part of the high-level deployment design process for a sensing network.

Two types of access should be considered:

1. **Is there *permission* to access the place or infrastructure?**

   The owner or governing authority of a place (or piece of prospective mounting infrastructure) may need to provide formal permission/approval for access to that area, and/or use of mounting infrastructure.

2. **Is it *practical* to access the place or infrastructure?**

   A place (or piece of prospective mounting infrastructure) must be practically accessible in a way that is cost-effective, not overly complex or time-consuming, and safe.

Access planning strategies

Several strategies can be used to minimise the complexity and cost of access to deployment locations and mounting infrastructure (note that not all of these will be achievable in every situation):

- Choose public space deployments where possible, avoiding restricted areas that might require special access permissions
- Favour infrastructure that your organisation owns (see note in the 'mounting infrastructure' section above)
- Avoid mounting infrastructure with complex mains power connection requirements
- Avoid mounting infrastructure in locations that require a road closure (or other major disruption) in order to gain access
- Avoid the need for a tele-lift or cherry picker for access, as hire costs can be substantial
- Avoid deploying devices within the hazard zone of high voltage overhead cables[2], as this often requires installers or maintenance contractors to have specialist licences. These contractors may not be readily available within your project's timeline, and their fees may be higher.

[2] Note that a height above the ground of 3.0m (a common standard height for sensing device deployments) is generally within the high voltage zone of urban power lines.

Additional resources

United States EPA* | *[A Guide to Siting and Installing Air Sensors]

The United States Environmental Protection Agency has produced a guide to the siting and installation of smart low-cost air quality sensing devices. This guide is broadly aligned with OPENAIR resources, though it is geared towards a U.S.-based audience.

Tracking California (and partners)* | *Guidebook for Developing a Community Air Monitoring Network

This extensive guide to community-led air quality monitoring contains a section on *Network design and implementation* (chapters 12, 13, and 14), covering some of the same topics addressed in this OPENAIR Best Practice Guide chapter. The full guidebook is worth consulting on all aspects related to deploying a smart low-cost sensing device network.

Associated OPENAIR resources

Best Practice Guide chapters

Sensing device deployment planning: detailed design

This Best Practice Guide chapter explores the detailed design of a smart air quality monitoring network. It builds upon high-level design activities, and provides guidance for planning and documenting the details of specific device deployments.

Supplementary resources

Sensing device deployment planning: high-level design template

This resource is a practical, step-by-step template for undertaking the high-level design of a smart air quality monitoring network. It covers how to identify general device deployment locations; identify suitable device mounting infrastructure; identify power supply options; develop device mounting solutions; and plan access and permissions.

A process and checklist for deploying devices

This resource provides a detailed, practical guide to activating and deploying smart low-cost air quality sensing devices.

Identify template

This template supports creation of a business plan and ‘data use action statement’ as strategic foundations for a smart low-cost sensing project.

Further information

For more information about this project, please contact:

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This Best Practice Guide chapter is part of a suite of resources designed to support local government action on air quality through the use of smart low-cost sensing technologies. It is the first Australian project of its kind. Visit www.openair.org.au for more information.

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