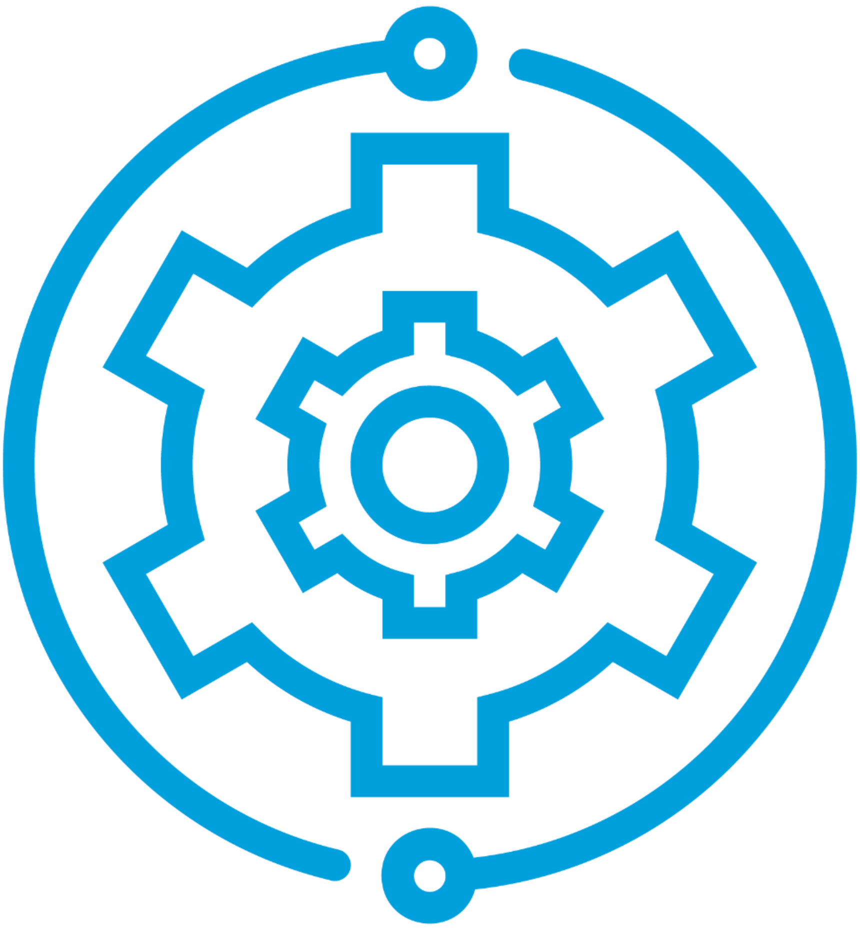
OPENAIR

Operational Network of
Air quality Impact Resources

Best Practice Guide

BP302 | Implement and operate

Air quality sensing device activation and deployment



Introduction

Air quality sensing devices don't generally work straight 'out of the box'. While the things that you need to do to get your devices activated and deployed may vary by product and vendor, certain practical steps will always need to be undertaken.

Activation of a sensing device includes all the steps required to prepare it for deployment: onboarding a device to your network, configuration, administration, testing, calibration, assembly, and labelling. Deployment of a sensing device includes the physical installation of the device, as well as the supporting activities that result in a fully commissioned, functional asset.

As someone who is responsible for planning and delivering a smart sensor network, you will no doubt want to gain a clear idea of what these steps are, and how much time, effort, and expense they will entail. This chapter should help you do this.

Who is this resource for?

This resource is intended for use by project staff tasked with planning and delivering a smart sensor network. It is written with local government in mind, but is applicable to other types of organisations.

It is also designed to be a useful reference for senior management who want to understand the complexities of sensing network establishment.

How to use this resource

This Best Practice Guide chapter provides you with a high-level, practical, step-by-step guide to activating and deploying low-cost smart air quality sensing devices. It is intended to give you an overview of these processes. Once you are ready to undertake specific tasks, it is recommended that you refer to *A process and checklist for deploying devices* (an OPENAIR supplementary resource), which provides additional details on each of the steps.

Before you engage with this resource, please refer to the two OPENAIR Best Practice Guide chapters dedicated to sensor deployment planning: *Sensing device deployment planning: high-level design* and *Sensing device deployment planning: detailed design*. These are essential preceding chapters that will help you work out where you want to deploy your sensing devices to best support the needs of your use case, and confirming practical installation details.

Prior planning

Before proceeding, please ensure that you have undertaken the following prior planning:

Impact planning cycle stage 2: Develop

- Chosen the model and quantity of air quality sensing devices that you will use, and selected a vendor. See the OPENAIR Best Practice Guide chapter *Sensing device procurement*, and OPENAIR supplementary resources *Technical requirements template* and *A guide to developing technical requirements.*
- Chosen, procured, deployed, and activated the communications technology that will support your data collection. See the OPENAIR Best Practice Guide chapter *Data communications procurement*.
- Developed a data management and data sharing plan. See the OPENAIR Best Practice Guide chapter *Sharing air quality data*.
- Developed a deployment location plan that details all deployment locations and mounting assets (a mounting asset is the physical infrastructure that you mount a device onto, such as a street pole), with all necessary approvals received. See the OPENAIR Best Practice Guide chapter *Sensing device deployment planning: high-level design.*
- Developed a detailed device installation plan, including procurement of components for specific mounting solutions. See the OPENAIR Best Practice Guide chapter *Sensing device deployment planning: detailed design.*

Impact planning cycle stage 3: Implement and operate

- Engaged an installation contractor.
- Developed a device management and operations plan. See the OPENAIR Best Practice Guide chapters *Sensing device troubleshooting: common problems and how to fix them* and *IoT system operations*.

Overview of the steps

Complete device activation and deployment is summarised in Figure 1.

Activation	1	Onboard devices to your network and IoT platform
	2	Device configuration
	3	Establish metadata schema, device administration, and management protocol
	4	Acceptance testing
	5	Prepare hardware for deployment
	6	Collocation calibration *(optional)*
Deployment	7	Installation
	8	Field testing
	9	Deployment metadata completion
	10	Commissioning

Figure 1. Summary of all activation and deployment steps

Part 1: Activation

The amount of work required for device activation and deployment will vary depending on the technology options chosen, and how they were procured. With proprietary 'data-as-a-service' choices, the technology vendor will cover many of the steps listed. With open-access technologies, particularly where you are integrating several different components, you may need to be more hands-on with all the steps in the process.

Step 1: Onboarding devices to your network and IoT platform

Practicalities

A sensor needs to be programmed to connect to a specific communications network and IoT platform. The programming process is called 'onboarding'. While the specifics will vary between products, the generic process is as follows:

- Devices are pre-programmed to connect with your chosen communications server.
- Communications server is pre-programmed to recognise your devices.
- IoT platform is connected to specific device codes within your communications server.

Challenges and considerations

Onboarding is commonly done by the device vendor, if they are also managing the IoT platform for you (this is the case for all proprietary products).

If you are connecting open-access devices with an IoT platform that is *not* associated with the device vendor, then you will probably need to do some or all of this step yourself, or negotiate collaboration between the device vendor and the platform provider. Ensure that you have sufficient in-house expertise to support this process.

Step 2: Configuring devices

Practicalities

Device settings are configured to support the needs of the project and include sensor settings, sampling rate, reporting interval, and communications settings (e.g. LoRaWAN spreading factor).

Challenges and considerations

This is often done by the vendor. However, you will still need to communicate your requirements to them. Some IoT platforms that are tied to specific device types may provide a user interface for configuring device settings.

Step 3: Establishing a metadata schema (and an administration and management protocol)

Practicalities

Metadata is any data that describes other data. It might describe your sensor telemetry, device details, administrative details, device deployment context, or data handling information. A metadata schema is a fixed framework for defining all aspects of metadata that will be used for your project.

1. Create a stand-alone metadata schema document to define all the metadata fields, units of measurement, and validated field entry lists that will be used in your project. For guidance on creating a deployment metadata schema to meet the needs of your project, please see the OPENAIR best practice guide chapters Sensing device deployment planning: high-level design and Sensing device deployment planning: detailed design , and the OPENAIR supplementary resource *Data labelling for smart air quality monitoring* .
2. Create a spreadsheet as a master metadata record that lists all the devices that you will be deploying, against a list of populated metadata fields that you have detailed in your metadata schema. Ensure that this document is accessible to key project staff, and establish access and editing protocols.

Challenges and considerations

All metadata should serve a purpose. When you develop your metadata schema, the following approaches are advised:

1. You should have a detailed device deployment plan in place before you start to develop your metadata schema. Ideally, you should have visited all your device deployment locations, taken detailed photographs, gained approvals, and defined solutions for mounting, power supply, and communications. By engaging directly with these practicalities, you will rapidly determine which deployment metadata fields are relevant to your project context and data use case. See the OPENAIR best practice guide chapters *Sensing device deployment planning: high-level design* and *Sensing device deployment planning: detailed design* for guidance on creating a device deployment plan.
2. Deployment metadata is critical for interpreting sensor data. If you are planning to address certain research questions using your data, then these may help with the choice of appropriate metadata fields. For example, if you wish to compare air quality from sensors at two different locations, then you may want to know that one is deployed two metres off the ground and the other at four metres.
3. You should engage with your data users to define a data schema that is practical and justified. Each metadata field should meet an end user need. End users in this context include the people who will be responsible for operating your sensor network (device and network management), as well as the users of the sensor data you are producing.

Step 4: Acceptance testing

Practicalities

Acceptance testing is critical for effective verification and troubleshooting after a device is purchased. This testing is conducted prior to device deployment, and aims to confirm two main things: 1) that the device functions correctly with respect to power usage, communications, and data capture; and 2) that reported data looks 'sensible' (in line with what you might reasonably expect). Once confirmed, any problems that arise following deployment can be attributed to the location, or to other issues (e.g. damage during installation).

To conduct acceptance testing, identify a secure indoor location (to which you have continued access) that will not be disturbed for three to seven days. It must have constant, reliable connectivity to your chosen communications technology (e.g. be within range of a nearby LoRaWAN gateway). Solar devices that lack a direct power input will need to be located in a north-facing window, with solar panels connected. Note that if your device includes meteorological sensors (e.g. for wind or rain), then acceptance testing must be done outdoors. Aim to find a suitable roof, balcony, or other secure outdoor area.

Challenges and considerations

When you do acceptance testing, the beginning of your data record for a device will not be tied to its final deployment location. For this reason, it is vital that you keep an accurate record of the deployment date, allowing you to create a cut-off point in the data record, and ensuring that acceptance test data doesn't accidentally get incorporated into future data analysis.

Step 5: Preparing hardware for deployment

Practicalities

Your devices will likely need to be assembled to be ready for deployment, which may mean attaching mounting brackets and connecting a power supply. It's a good idea to box up each complete set of hardware with all components and fixings required to avoid any confusion on the part of installers. Make sure you add weather-proof labels to devices (e.g. name, serial number, owner, contact number). You should also prepare detailed installation documentation and instructions for use by an installer and add this supporting paperwork to each box.

For details on what this paperwork should include, please see the OPENAIR supplementary resource *A process and checklist for deploying devices*. Finally, ensure that device-specific metadata is up to date in your master metadata record, to reflect any changes to your initial deployment plan now that you are finalising the details.

Challenges and considerations

Some installers may not be familiar with the task of deploying sensing devices, so the more time and effort that you invest up front, producing clear and detailed documentation and instructions, the lower the chance of mistakes and problems further down the track. Annotated photographs are highly recommended.

Remember that devices are often shipped without batteries, so you will most likely need to procure and install them yourself. If you need to courier or mail complete device deployment packages to an installer, keep in mind that posting batteries is complicated and could delay your project. Ideally, try to engage a local installer who can collect packages in person. If you need to post batteries, check with your courier company regarding their policy.

Step 6: Collocation calibration (*optional*)

Practicalities

Collocation calibration involves temporarily deploying air quality sensing devices in immediate physical proximity to a regulatory air quality reference station that is itself situated in or close to the area where you intend to deploy your low-cost devices. The reason for doing this is to understand how the data from your low-cost sensing devices compares to data from highly trusted reference equipment, and how local environmental conditions interfere with sensor performance. This comparison allows determination of correction factors, supporting calibration of the device and more accurate (and usable) data output.

The OPENAIR best practice guide chapter *Sensing device calibration* (which is the chapter directly before this one) explores device collocation in detail. That chapter covers why collocation calibration is important, helps you decide whether you should do it for your project, and guides you through the practical steps necessary for undertaking it. The following is a summary of those steps:

1. Identify a regulatory air quality monitoring station in your local area and contact the relevant authority to secure approval and access.
2. Visit the site to confirm practical details (mounting, power, communications, etc.), and work with the regulatory authority to ensure the best possible methodology.
3. Install your devices and allow at least three days to confirm and verify data flows and expected device functionality, followed by at least one month of data collection.

Challenges and considerations

Collocation calibration takes time (at least a couple of months of planning and delivery), can be a significant expense, and may or may not be a critical step for your project. Please see the OPENAIR supplementary resource *A process and checklist for deploying devices* for more guidance on this.

Part 2: Deployment

Step 7: Installing devices

Practicalities

Installation refers to the process of physically installing a sensing device and its supporting infrastructure at a fixed operational location. This may be done by external contractors or by staff within your organisation. You will need to arrange collection of all equipment and paperwork, and ensure that installers are fully briefed on critical details before they carry out the work. Afterwards, installations should be methodically documented with photographs and other 'as-installed' metadata.

Challenges and considerations

There is a significant risk of installers failing to complete installations according to approved methodology, or failing to document installations correctly, which can result in significant delays to the project. To help avoid mistakes, make extra time for quality control at the start. The ideal approach is to undertake an initial trial installation where you are present on-site with the installer. Go over everything with them step by step, and make sure that you are both happy with the process and the result. This is also an opportunity to discuss installation records and any photographs you would like taken. If it is not possible for you to be present for a trial installation, aim to have a dedicated briefing meeting with the contractor to go over all the components and the paperwork.

Step 8: Field testing

Practicalities

Following device installation, allow a period of at least one week[1] to verify device installation, device operation, and data quality in the field. There are several steps to this process that are detailed in the OPENAIR supplementary resource *A process and checklist for deploying devices*. It may require changes to the planned network design, such as installing devices in alternative locations. Ensure that you update your metadata records with any deviations that occur. You should also verify the functionality of your IoT platform by checking that devices are visible, with data appearing as expected.

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[1] *One week is the recommended minimum for data collection to verify device functionality. However, please note that the verification and troubleshooting process can take much longer than this.*

Challenges and considerations

Be careful about using your IoT platform as the sole means of verifying device functionality. While it is reasonable to start there, any apparent issue with a device needs to be followed up at the level of your communications server, which sits at the lowest level of your data stack and should have an accessible user interface of its own.

By reviewing device status and data packets at the level of the communications server, you can rule out any faults occurring within the IoT platform (e.g. a bug in a data decoder or data visualisation element). You can also check whether the fault lies within the communications layer itself (e.g. a gateway or server outage). Ensuring access to multiple levels of your data stack allows you to pinpoint where problems are occurring, and is therefore a critical capability for troubleshooting and ongoing operational management of your sensor network.

Step 9: Completing deployment metadata

Practicalities

Following installation and field testing, there will likely be ‘as-installed’ information that deviates from your deployment plan, as well as records (such as installation date and time) that need to be updated in your master metadata record. Updated metadata will also require entry into your IoT or data platforms, so be careful to follow agreed procedures for editing and informing your technical team, vendors, and any data users who may be impacted.

Capture as much initial fixed documentation about the installed network as you can. It is good practice to create a supplementary ‘as-installed’ document that captures photographs of each device installation. A digital map (e.g. Google Maps) is helpful as a fixed visual record of device locations.

Challenges and considerations

The time required to fine-tune a data schema and populate all the ‘as-installed’ metadata for even a modestly sized sensing device network should not be underestimated. Deployment (particularly if you are new to it) can be a steep learning curve. Your metadata schema is likely to require updates (e.g. new fields, validations, or associations between fields) based on realities that only come to light through practical engagement with the deployment process. These updates may then need to be implemented within your IoT and data platforms, which may require extensive technical support. The process of capturing the metadata entries for all the fields can also be protracted, as it is contingent upon completion of the verification and troubleshooting process (which can itself last for weeks or even months). You should anticipate this and allow extra time in your project delivery plan.

Step 10: Commissioning

Practicalities

Commissioning is the final step of the deployment process, culminating in sign-off by your organisation and an official shift into an 'operations' phase. Your organisation will likely have existing policy relating to this; however, the critical tasks will likely include compiling and publishing 'as-installed' documentation, sign-off of all contracted work, and informing relevant stakeholders.

Challenges and considerations

Once you commission your new network, it is cause for celebration; however, the hard work does not end there. Regardless of the technology choices you have made, or the complexity of your deployments, you are going to need to actively manage your network. Devices need to be regularly checked to ensure optimal functionality, and routine maintenance is advisable to avoid failures.

OPENAIR resources that provide further guidance on this include the Best Practice Guide chapters *Sensing device troubleshooting: common problems and how to fix them* and *IoT system operations*, and the supplementary resource *Sensing device troubleshooting: extended guide.*

Associated OPENAIR resources

Best Practice Guide chapters

Sensing device deployment planning: high-level design

This Best Practice Guide chapter explores the high-level design of a smart air quality monitoring network. It provides general guidance for selecting where to deploy devices, what to mount them on, how to mount them, and how to support their operation.

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.

Sensing device troubleshooting: common problems and how to fix them

This Best Practice Guide chapter introduces a framework of common problems that can arise with smart low-cost air quality sensors and the provision of useful data. It includes some practical information to help diagnose issues, fix them, and mitigate against reoccurrence.

Sensing device procurement

This Best Practice Guide chapter provides guidance on the selection and procurement of smart low-cost air quality sensing devices. It explores critical considerations relating to the design and functionality of devices and the quality of the data they produce, supporting procurement choices that are appropriate to the needs of a project and organisation.

Data communications procurement

This Best Practice Guide chapter explores the various communications technologies that can support smart low-cost air quality sensing, and provides advice on selecting technologies that are appropriate to a project and organisation.

IoT system operations

This Best Practice Guide chapter provides guidance on the technical operation of an air quality monitoring network as a complete IoT system (comprising multiple devices, communications systems, software/platforms, databases, and digital services). Effective operation of these systems ensures a reliable supply of air quality data, and ensures that data is stored, accessed, and used in accordance with the needs of a project and organisation.

Sensing device calibration

This Best Practice Guide chapter provides guidance on the calibration of smart low-cost air quality sensing devices. It discusses calibration, co-location, decision-making, and developing and following a plan.

Sharing air quality data

This Best Practice Guide chapter provides guidance on the sharing of air quality data. It explores the process by which a local government might assess data to determine its shareability, and presents a series of practical options for implementing data sharing.

Supplementary resources

A process and checklist for deploying devices

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

Technical requirements template

This template is an extended, step-by-step tool that supports the development of technical requirements for a smart air quality monitoring project. These requirements define the details of technologies (sensing devices, platforms, and services) that can meet the specific needs of a project, and are intended to support procurement decision-making.

A guide to developing technical requirements

This resource is a companion guide to the technical requirements template.

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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