OPENAIR

Operational Network of Air quality Impact Resources

Technical requirements template

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Table of Contents

Overview

This *Technical requirements template* is part two of a multi-part business planning process created for the OPENAIR project. This template is designed to help local governments develop a technology requirements plan for smart air quality sensing devices and supporting digital platforms and services. Before commencing this template, you should have already completed the *Identify template*.

The OPENAIR supplementary resource *A guide to developing technical requirements* provides information required to help you complete this template and should be viewed in tandem.

WHAT IS A TECHNOLOGY REQUIREMENTS PLAN?
A technology requirements plan seeks to identify a set of technical criteria for the selection of commercially available technologies that align with the needs of a chosen project, and with the broader practical/institutional/economic context that you are operating within.

How to use this resource

Work through each section, respond to the prompts and develop the content for your own technology requirements plan.

This template will help you to:

- identify the criteria for sensing devices that support your chosen data use case
- identify the criteria for digital platforms and services that support your chosen data use case.

Other templates in this series address the following (not covered here):

- develop an implementation timeline considering deployment and operations requirements
- design your initiative for data interpretation and management
- embed evaluation in your design.

Section 1: Choosing a smart air quality sensing device

We have identified ten criteria to consider when choosing a smart air quality sensing device. In most cases, the various options available to you have pros and cons and the best one for you will depend upon what you are trying to achieve and the context and constraints that you are operating under.

Table 1 summarises your needs against these criteria and can be used to support your procurement process. Work through this section to understand the nine criteria in detail and the choices that will best suit your data use case, and then return to this table to summarise your plan.

Table 1. Summary performance requirements

Criteria	Key Performance Requirements	
1. Air quality concerns	Primary pollution source of interest	
	Secondary pollution source (see the OPENAIR framework for categorising air quality sensing devices[1])	
2. Data application area	Your data application tier	☐ 1 ☐ 2 ☐ 3 ☐ 4
3. Sensor performance and technical requirements	For each pollutant of interest, we have defined sensor performance metrics that will meet the specific needs of our project	☐ Yes ☐ No
	Choosing an independently benchmarked device is an important criterion	☐ Yes ☐ No
4. Communications technology	First choice	
	Second choice	

[1] See the OPENAIR supplementary resource *A framework for categorising air quality sensing devices*

Criteria	Key Performance Requirements	
5. Proprietary vs open technology	The commercial option that is best suited to our needs is	☐ Proprietary technology ☐ Open technology
6. Environmental factors and robustness	Ingress Protection (IP) Rating An IP rating is a certification proving a product meets a certain standard of water and dustproofing/resistance. First digit: Solid particle protection Second digit: Liquid ingress protection	☐ Not important ☐ at least IP 64 (Dust tight and protected against splashing water) ☐ at least IP 67 (Dust tight and protected against the effects of temporary immersion in water)
	Solar Radiation Shield	☐ Yes ☐ No
	Salt corrosion is a concern, and we will choose materials that can resist it.	☐ Yes ☐ No
	Obtain at least one reliable testimonial in favour of our chosen device	☐ Yes ☐ No
7. Device lifetime	Our chosen use case requires devices to last reliably in the field for:	☐ A month or two ☐ Up to 1 year ☐ 1-3 years ☐ Several years / ongoing
8. Power supply	Our primary power supply for devices will be	☐ Battery only ☐ Solar + battery ☐ Mains power

Criteria	Key Performance Requirements	
	We anticipate the need for a hybrid power supply approach	☐ No ☐ Yes ☐ Battery only / solar + battery ☐ Solar + battery / mains
9. Size, form, and aesthetics	Pole clutter is a concern	☐ YES ☐ NO If YES, we intend to address it as follows (briefly describe strategy):
	Large solar panels may be necessary in locations with marginal solar exposure	☐ YES ☐ NO If YES, ☐ We accept the aesthetic implications of this OR ☐ We will investigate mains power as an alternative
	The aesthetic of the device mounting solution is important to us	☐ YES ☐ MAYBE ☐ NO
	We anticipate needing to develop a custom mounting solution	☐ YES ☐ NO ☐ UNSURE

Criteria	Key Performance Requirements	
10. Modularity	How important is device modularity to you?	☐ Device modularity is not that important for us ☐ Modularity might be important for us as a cost-effective way to evolve our sensing strategy in the medium term ☐ Modularity might be might important for us as a cost-effective way to extend device lifetime ☐ Modularity is an important criterion that we should give strong consideration to for reasons of flexibility AND device lifetime
	Our chosen modularity strategy is:	☐ Option 1: Modularity from the outset ☐ Option 2: No Modularity—choose devices that monitor 'the usual suspects' ☐ Option 3: No Modularity—'simple, affordable, disposable'

1. Air quality concerns

Different pollution sources produce different pollutants of concern. In each case, there may also be specific pollutants of high interest. List these below.

Primary pollution source of interest (e.g., road traffic)	
Secondary pollution source of interest (optional)	

Please refer to Section 1 of *A guide to developing technical requirements*, in the section titled *1. Air quality concerns* to determine your priority pollutants. List these below.

Priority pollutant of interest (e.g., $PM_{2.5}$ [2])	
Secondary pollutant of interest (optional)	

2. Data application area

Low-cost smart air quality sensing devices range in price enormously, from a couple of hundred dollars to several thousand dollars. Even the most expensive of these are still classed as 'low-cost' relative to regulatory equipment, which costs tens or even hundreds of thousands of dollars.

When selecting sensing devices, keep in mind that obtaining the highest quality data is not always the aim. Instead, you should understand the minimum data quality that will support your chosen *application area* and seek a balance between device performance and cost. Spend what you need to get the job done but avoid over-investing to achieve a data quality that exceeds your requirements.

The OPENAIR *Framework for categorising air quality sensing devices* has been developed to associate air quality sensing devices of varying performance and quality of data output, with four 'tiers', each of which roughly characterises a type of data use (or data application area). It is of broad relevance to any local authorities engaging with air quality data in the Australian context and has been adapted from previous work by the US Environmental Protection Agency (United States Environmental Protection Agency, 2022). To review the framework and determine which tier best suits your focus area, please refer to Section 1 of A *guide to developing technical requirements*, in the section titled *1. Data application area*.

The tier of low-cost sensors that best applies to our focus area is:

☐ 1 ☐ 2 ☐ 3 ☐ 4

3. Sensor performance and technical requirements

Please refer to Section 1 of *A guide to developing technical requirements*, in the section titled *3. Sensor performance and technical requirements* to determine your data quality parameters. List these in the following table.

[2] PM (particulate matter) refers to airborne solids or liquids. Its size is measured in micrometres and is indicated by the subscript. E.g. $PM_{2.5}$ has a diameter of 2.5 micrometres or less. (NSW Health, 2020)

Performance specification	Pollutant 1 *[Insert here]*	Pollutant 2 *[Insert here]*	Pollutant 3 *[Insert here]*
Target concentration What is your target concentration value, if any?			
Target range What is your minimum and maximum target pollutant concentration range? This should be quoted in ppb for gases and ug/m^3 for particulates. *Note: on a data sheet, the full range between zero and the maximum will be quoted*			
Maximum error What is the maximum acceptable percentage error in the reading? Is this flexible throughout the range, or constant throughout?			
Reporting interval What is your minimum sensor sample rate in minutes?			
Resolution What is your minimum required resolution for your target pollutant?			
Operating temperature range What is the minimum and maximum temperature your sensor will be operating in?			
Operating humidity range			

Performance specification	Pollutant 1 *[Insert here]*	Pollutant 2 *[Insert here]*	Pollutant 3 *[Insert here]*
What is the minimum and maximum humidity your sensor will be operating in?			

Based on our planned use case, we believe that choosing an independently benchmarked device is an important criterion.

☐ Yes ☐ No

4. Communications technology

Multiple communications options exist for low-cost air quality sensing devices, each with pros and cons. You cannot procure a device without having a clear idea of which communications technology is right for your use case.

Before considering which communications option is right for you, it is worth answering a more fundamental question: Do you need live data?

Older style data loggers have been used by local authorities for years very effectively. They don't allow for real-time insights or any of the sophisticated smart city integrations (e.g. remote control of device settings) that are possible with live IoT devices, however, they are still worth considering. If you just want a low-cost one-off snapshot of air quality in a few key locations, or have difficult with wireless connectivity in a specific location, these may make best sense in some situations.

THE BENEFIT OF LIVE DATA AND SMART SENSORS. THEY:

- respond to events as they happen
- provide real-time updates to council and the community
- combine with other live data streams for integrated, responsive, and increasingly sophisticated smart city outcomes (e.g., traffic data + air quality data + pedestrian counts ➔ live traffic management thresholds)
- support advanced data analytics (e.g., using collected data for automatic forecasting and predictions)
- Have ‘over the air’ device management (rather than ‘set and forget’)
- identify and respond to faulty devices as issues occur, rather than finding out months later.

Choose a communications technology that is best suited to your use case

Once you are sure that you need a live data feed from your sensors, you should review the options and make an informed decision. Please refer to Section 1 of *A guide to developing technical requirements,* in the section titled *4. Communications technology* to help you review common communications options and their strengths and weaknesses relative to your needs.

Once you feel comfortable with a decision, record your first and second choice below:

First choice for a communications technology	
Second choice for a communications technology	

5. Proprietary vs open technology

Most commercially available low-cost air quality monitoring devices are proprietary technologies sold through a 'technology as a service' model. The customer buys a complete package of hardware, software, and data services; in some cases, does not even own the hardware, instead paying a subscription for data access.

Open technology refers to devices, communications, software, and data platforms that prioritise transparency, accessibility, and interoperability. A formal set of design principles behind open technology is increasingly prescribed as best practice in IoT and smart city policy and standards.

Despite an emerging best practice consensus in favour of open technology, there are pros and cons to both options, and for many local governments, proprietary (or hybrid) options may be the most appropriate. Indeed, several significant and highly successful global case studies have involved the use of proprietary low-cost air quality monitoring technologies. Please refer to Section 1 of the *Guide to Developing Technical Requirements*, in the section titled *5. Proprietary technology vs open technology*, which will help you decide which approach is best for you.

The commercial option that is best suited to our needs is:

- ☐ proprietary technology
- ☐ open technology.

6. Environmental factors and robustness

Regional climate and the specific microclimate of a location where you intend to deploy a device determine the conditions that the device will be exposed to, supporting a requirement for a certain level of device robustness and functionality. Extremes of temperature, direct weather exposure, high humidity, and high salt aerosols (coastal) can take their toll on devices across their functional lifetime. Highly robust devices must be engineered to a high standard, using the highest-grade materials and parts, resulting in a premium price tag. Less robust options may still suit your actual needs and may be more affordable. Therefore, it is important to understand your robustness needs and ensure that you procure to meet them, avoiding over-engineered options that carry unjustifiable expenses.

Please refer to the section titled *6. Environmental factors and robustness in A guide to developing technical requirements* to help you determine your device’s robustness needs and make decisions that support those needs.

Our robustness needs

Given our intended use case and planned deployment locations, what level of robustness to environmental pressures does our device need?

- ☐ Low
- ☐ Moderate
- ☐ High

Considering our robustness needs, we need a device with the following attributes:

Our device should have an IP rating of	☐ Not important ☐ at least IP 64 ☐ at least IP 67
Our device should have a solar radiation shield	☐ Yes ☐ No
Materials used in our device, mounting brackets and fixings should be tolerant of high salt conditions	☐ Yes – Marine grade stainless steel ☐ Yes – Galvanised steel ☐ Yes – UV-resistant plastic ☐ Yes – Other: ☐ No – N/A
It is important to us that our chosen device AND/OR its manufacturer has a proven track record for quality and performance	☐ Yes ☐ No
It is important to us that the manufacturer provides at least one reliable testimonial in favour of the chosen device	☐ Yes ☐ No

7. Device lifetime

Your chosen use case will determine your requirements for the device's lifetime. Different commercial device options will have different functional lifetimes. The functional lifetime of a sensing device relates to a complex mix of factors, which should be considered to help you choose an option that meets your needs.

Please refer to Section 1 of the *A guide to developing technical requirements,* in the section titled *7. Device lifetime*, which will help you determine your lifetime requirement and establish a series of criteria that will help you support it.

Our lifetime requirement

Our chosen use case requires devices to last reliably in the field for:

- ☐ a month or two
- ☐ up to 1 year
- ☐ 1-3 years
- ☐ several years / ongoing.

Checklist

The following table contains advice that may help you to choose a device with the most appropriate functional lifetime. It is a summary of a more detailed table in *A guide to developing technical requirements*.

Attribute of a device that affects its functional lifetime	Advice	Check
The complexity of a device	**Avoid unnecessary complexity** Understand the functional attributes needed in a device to meet the needs of your use case and aim to take a lean approach to choose a device option that meets these needs but does not exceed them.	☐ We are clear about our needs here OR ☐ We need to do more research
The quality of a device	**Balance quality against needs/budget** Favour the highest quality device option for your needs, that still fits your budget (with consideration total number of devices, maintenance costs, lifetime of project, etc.)	☐ We are clear about our needs here OR ☐ We need to do more research
The lifetime of gas sensors	**Consider drift correction functionality** If you expect to be dealing with high gas pollution levels, check that a prospective device includes gas sensor drift correction functionality, either onboard or as cloud-based processing.	☐ Drift correction is important to us OR ☐ Not Applicable

Attribute of a device that affects its functional lifetime	Advice	Check
The lifetime of particulate sensors	**Be aware of the limits imposed by high pollution environments** If you expect to be dealing with high levels of particulate pollution, understand there are no clear options for low-cost sensors that can mitigate the impact of this on sensor lifetime, and factor this into your business case.	☐ We anticipate high particulate pollution and accept the limits this imposes OR ☐ Not Applicable
Battery life	**Lithium-Ion with charge protection** Choose Lithium-ion batteries where budget allows (for battery-only and solar + battery setups) If using solar, check that the device has built-in protection to prevent battery charge running too low and damaging recharge capacity. Also ensure that the solar panel is large enough to meet demand in the planned deployment location, because consistent undercharging can damage the operational lifetime of the battery.	☐ Li-Ion is preferred ☐ Battery charge protection is preferred ☐ Solar capacity meets the needs of the device and the location
Communications coverage and strength	For LPWAN technologies—which tend to be the only type compatible with battery-only power supply—higher power demand is associated with a higher 'spreading factor', which can be thought of as 'how hard the device tries to be heard when it transmits its data'. A higher spreading factor is often necessary in locations with weaker signal coverage/strength (e.g., further from a gateway). The result: if you are deploying somewhere with weak communications coverage, your battery won't last as long.	☐ Dynamic spreading factor is something we will investigate OR ☐ Not Applicable (e.g., not using LPWAN; Strong signal; Not reliant on batteries only)

Attribute of a device that affects its functional lifetime	Advice	Check
Sampling rate and reporting interval[3]	**Understand your specific place-based data requirements** If you plan to focus air quality monitoring in a very specific and relatively confined locality (such as a single transport hub) and your aim is to understand highly localised pollution sources and dispersal patterns, then higher sampling rate and reporting interval may help. If this is a consideration, consider mains power or solar if lifetime of the device is also a concern.	☐ We think a higher sampling rate and/or reporting interval may be relevant and we will explore ways to support this. OR ☐ Not Applicable
Modularity	**A degree of modularity might help** Consider a modular device if lifetime is a big factor for you. A replaceable battery is the most important feature in this instance. Replaceable gas sensors are also worth looking at. Confirm all costs and timeframes associated with component replacement with the device supplier as part of initial procurement negotiations. *Note: modular devices may compromise on compactness.*	☐ Replaceable battery is preferrable ☐ Replaceable gas sensors are preferred OR ☐ Not Applicable

8. Power supply

When you procure a sensing device, you must decide on a power supply option that supports your chosen use case and works within the practical constraints of your project. This section will help you to make an informed power supply decision.

Please refer to Section 1 of *A guide to developing technical requirements,* in the section titled *8. Power supply.* This will help you understand the power demand of your chosen device and how best to meet it given a combination of device attributes, deployment context and operations.

Battery, solar, or mains?

All sensing devices require a power supply, and the options tend to fall into one of three categories:

[3] See *A Guide to developing technical requirements* for an explanation of these concepts.

Battery only	A device is fitted with a battery that discharges slowly over the entire deployed lifetime of the device. This period can be several years in low power devices.
Solar + battery	A device is fitted with a battery recharged by a solar panel. This provides a renewable power supply that lasts if the battery remains operational. Batteries are ultimately restricted by a total number of power cycles, limiting their lifetime (variable, but generally several years).
Mains	A device is connected directly to mains power. This removes all constraints on power usage associated with batteries and solar power.

To determine the most appropriate power supply option for your device, you must first understand its power demand. This tends to be the product of two things:

- the fixed device attributes of your chosen device
- various deployment, configuration, and operational factors.

a) The implications of fixed device attributes on power demand

The main fixed attributes of a device that impact its power demand are: the type of sensors used, the communications technology used, and the amount of onboard processing.

We have reviewed the options for these attributes, which indicate the following power supply options:

Battery only	☐ Preferred option	☐ Viable alternative option	☐ Not viable
Solar + battery	☐ Preferred option	☐ Viable alternative option	☐ Not viable
Mains	☐ Preferred option	☐ Viable alternative option	☐ Not viable

b) Deployment, configuration, and operational factors that might impact your preferred power supply option

We have reviewed the critical deployment, configuration and operational considerations that relate to power supply, and we have decided on the following approach:

Locations with marginal communications signal strength	☐ We will be using LoRaWAN or Sigfox communications and we anticipate battery life challenges associated with marginal signal for devices in some locations. If YES, then:

(LPWAN only)	☐ We therefore plan to discuss the configuration of a custom or dynamic spreading factor with the supplier OR ☐ Not a concern
Reporting interval	Based upon an assessment of our data use needs, we will set a reporting interval for each device as: ☐ 10 minutes or less *[Caution: If you are using batteries only, or batteries + solar, you should discuss the viability of this short reporting interval with your device supplier. You may need to use a larger solar panel and/or a larger external battery to compensate]* ☐ 15 minutes *[Borderline: raise power use relative to reporting interval with your device supplier as it may be an issue]* ☐ 30 minutes ☐ 60 minutes ☐ > 60 minutes *[Probably fine: reporting intervals of 30 minutes or greater should be viable for most devices]* *Additional note: Ambient temperature and humidity monitoring devices using battery only power supply are very low power users to begin with, so low reporting intervals are less of a concern. Air quality monitoring devices can use a lot more power, which can result in a more marginal power budget where reporting interval plays a more significant role.*
Locations with low solar exposure	We anticipate that low solar exposure may be a challenge in multiple locations ☐ Yes ☐ No If YES ☐ We will procure a larger solar panel to compensate AND/OR ☐ We will find a way to access mains power in these locations

The availability of locations with accessible mains power	☐ We lack options for locations with accessible mains power and intend to focus on solar + battery options. OR ☐ Our chosen device option must be mains powered, and we understand the limitation this places on deployment location options. ☐ Our organisation owns suitable assets (e.g., street poles) with accessible mains power, which we anticipate can be accessed to power our sensors. AND/OR ☐ We have access to mains power on other assets and we believe that achieving approval for connection is achievable without significant time/effort/cost.
Intermittent mains power	☐ We are NOT considering locations with intermittent mains power OR ☐ We ARE considering locations with intermittent mains power, and we will investigate the use of a battery and power management system to enable deployment in these locations.
Cost of installing mains power	☐ NA (We do not plan to use mains power ☐ We plan to make use of mains power and we understand that the cost of installation can be high, often exceeding the cost of the hardware itself.
Time for installation approvals	☐ NA (We do not plan to use mains power) ☐ We understand that the process of approving mains power installation has the potential to significantly delay device deployments ☐ We will start the approval process as early as possible by obtaining installation specifications from the device supplier at the earliest opportunity.
Operational costs	We anticipate the following operational costs relating to our chosen power supply option: ☐ Very low (battery only device with no battery replacement planned) ☐ Low-Medium (Mains power fees and administration)

	☐ Medium (Solar panel maintenance) ☐ High (battery replacement for entire device network)

Based upon the planned combination of device attributes and deployment, configuration and operational factors, we believe that the most appropriate power supply option for our devices is:

- ☐ battery only
- ☐ solar + battery
- ☐ mains power.

We anticipate the need for a hybrid power supply approach:

- ☐ no
- ☐ yes
  - ☐ battery only / solar + battery
  - ☐ solar + battery / mains

Additional notes: ____

____

9. Size, form, and aesthetic

The size, form and general aesthetic of devices can matter a great deal if they are to be deployed in public places. It may often be the case that more compact, and aesthetically designed products have a higher price tag. You should have a clear idea of your aesthetic requirements and make sure that you procure a device that meets them.

Several specific considerations can be addressed. Please refer to Section 1 of the *Guide to Developing Technical Requirements,* in the section titled *9. Size, form, and aesthetic.* This guide will help you understand these considerations in more detail, before completing the following table.

Pole clutter	Pole clutter is a concern: ☐ YES ☐ NO If YES, We plan to address pole clutter in the following ways: ☐ Option 1: Choose a compact all-in-one design ☐ Option 2: Consider combining multiple sensing needs in one device ☐ Option 3: Mount the device inside a smart pole (CAUTION ADVISED) Other (note details): ____ ____
Size of solar panel	☐ NA (we are not using solar) OR We need to deploy solar-powered devices in locations with marginal solar exposure ☐ YES ☐ NO If YES, ☐ We accept the aesthetic implications of this OR ☐ We will investigate mains power as an alternative
Mounting solutions	The aesthetic of the device mounting solution is important to us ☐ YES ☐ MAYBE ☐ NO We have a clear idea of how we can fasten devices to our chosen mounting infrastructure (e.g. Council-owned street poles) ☐ YES ☐ NO (more investigation required) We anticipate needing to develop a custom mounting solution ☐ YES ☐ NO ☐ UNSURE

10. Modularity

Some commercially available sensing devices are designed as modular systems that allow different sorts of sensors to be added or removed.

THERE ARE TWO MAIN BENEFITS OF MODULARITY:

1. **Flexible sensing to support evolving data needs:** You might start with a focus on particulates and NO_2, but you could decide later that you also want to monitor CO_2. Rather than installing separate devices, having the option to add a CO_2 sensor to your existing devices can be both cost effective and operationally efficient. This ability to expand the functionality of your devices extends beyond air quality monitoring and may connect with other council priorities (e.g., noise monitoring).
2. **The ability to replace sensors and extend the operational lifetime of a device:** Gas sensors degrade chemically over time, and particulate sensors can become fouled through deposition. These processes place limits on the lifetime of sensors. If sensors can be replaced, the overall lifetime of a device might be significantly extended. The service cost, which might include device retrieval, shipping, and reinstallation, should be considered.

Let's establish how important device modularity is likely to be to you

Please refer to Section 1 of *A guide to developing technical requirements*, in the section titled *10. Modularity* to help you understand whether modularity might be an important criterion for you. Figure 1 below summarises a more detailed table in the guide.

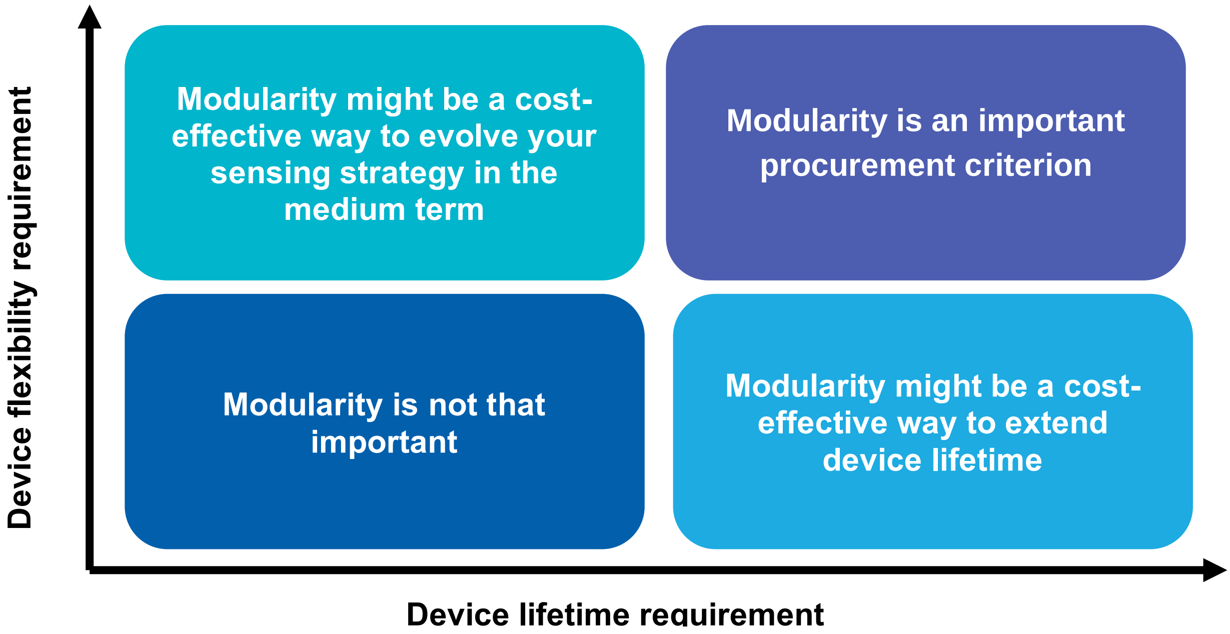

Figure 1. Summary of considerations for modularity requirements for device lifetime and flexibility.

Review the flexibility/lifetime requirements matrix and select one of the following outcomes:

☐ Device modularity is not that important for us.

☐ Modularity might be important for us as a cost-effective way to evolve our sensing strategy in the medium term.

☐ Modularity might be might important for us as a cost-effective way to extend device lifetime.

☐ Modularity is an important criterion that we should strongly consider, for reasons of flexibility AND device lifetime.

Now consider which of the following device modularity strategies is best suited to your situation:

☐ **Option 1: Modularity from the outset**

Support future flexibility by procuring a modular device that can have new types of sensors added to it later. Choose sensors that meet your needs now and know that you can add new ones later, extending the operational lifetime of the device.

☐ **Option 2: No modularity - devices that monitor 'the usual suspects'**

Procure non-modular devices that measure several common pollutants associated with multiple issues and sources (e.g., $PM_{2.5}$, NO_2). This is a reasonable compromise if other selection criteria mean that you need to downplay the importance of device modularity. This strategy will place you in good stead for general air quality monitoring over the short to medium term. You may need to adapt your approach and procure different technologies over the longer term, but for now this is not a bad starting point.

☐ **Option 3: No modularity—'simple, affordable, disposable'**

Avoid complexity and just go for a simple low-cost device option that measures the specific pollutants of interest in the short term. This can be the most effective pathway to a quick win. You may need to decommission the devices and upgrade to something else in a year or two, but there are a lot of unknowns, and so long as you keep the costs below an acceptable level, it may be ok to experiment and move on when the time comes.

Section 2: Choosing supporting data services and platforms

When you purchase and deploy smart air quality monitoring devices, you will need to have several data services and platforms in place to support them. We can think of these as **components**, each with a specific set of functionalities, which together with some associated services, make up a complete 'data architecture' (alternately referred to as a 'technology stack'). Regardless of the approach you take, you are going to need all these components to be accounted for. See Figure 2 for more information.

1. Define your needs for each component of the data architecture

We tend to present a data architecture as a vertical technology stack. Data is produced at the base and moves up through multiple component layers that add increasing complexity and value.

For each component of the data architecture, you should review whether you have existing capacity (your own assets or services) that can be used to meet the needs of your new smart air quality monitoring project. This has already been addressed in the OPENAIR *Identify template* in Part 3, Section D (Your existing assets), which we recommend you refer to. We will now translate that information into actions.

Different strategies will demand different levels of in-house technical knowledge, skills, and capacity. You should review your response to Part 3, section A of the *Identify template* (*Your people*) to remind yourself of your capacity in this regard.

Data users		
User interfaces (laptop, mobile, tablet, etc.)		
Application enablement	**Air quality data applications**	End user business and IoT applications: • data discovery and sharing (e.g. public dashboard; open data portal; custom API) • developer services.
Intelligence enablement	**Analytics and visualisation platform**	A user-facing dashboard that might incorporate maps, customisable graphs, and more advanced data analytics tools (e.g. GIS; digital twins; machine learning/AI).
	Data management and storage *[Data platform]*	Device telemetry (sensor readings) must be structured and stored in a way that is secure, searchable, and accessible. Storage options tend to be cloud-based third-party services (commonly Amazon or Microsoft) that are connected to data management systems, which structure data and manage user access.
Connection management	**Device hosting and management + basic data interpretation** *[IoT platform]*	You will need a contract with a service provider that hosts devices in a digital platform. Device management involves the onboarding and commissioning of new devices and their subsequent management, with alerts in place for failures and errors. Be aware of your basic data interpretation requirements (like humidity interference correction for particulate data, and calibration and drift correction for gas data), and communicate these before proceeding.
Connectivity + edge gateway	**Communications**	You will need a contract with a communications provider that supports the transmission of live data from devices to a central online management location. Your chosen communications solution might involve local government-owned infrastructure (gateways), or you might engage a telecommunications provider and make use of their existing infrastructure.
IoT end point	**Devices** (IoT end point)	Physical digital hardware that produces and transmits data.
The physical world		

Figure 2. Basic components of data architecture for a sensing network

Please now refer to Section 2 of *A guide to developing technical requirements*, in the section titled *Define your needs for each component of the data architecture*. A series of tables are designed to help you determine actions for your existing data services and platforms. There may be more than one option worth considering where new solutions are required. Once you have reviewed the tables, capture your actions in the summary table below.

	Your action	**Details if known** *(e.g., specific technology, provider, etc.)*
Devices	☐ No action required *You have existing sensing devices installed, ready to install, or able to be relocated, that will support your data needs*	
	☐ Procure more devices of the same type	Make: Model: Number of additional units required:
	☐ Procure new types of device (*You may require more than one)*	**New device type A** Make: Model: Number of units required: **New device type B** Make: Model: Number of units required:
Communications	☐ No action required (an existing option is available) OR ☐ Set up or expand a new local communications network to	Our preferred communication technology is (refer to your answer from *Section 1 4. Communications technology* of this template): ____________________

	Your action	Details if known *(e.g., specific technology, provider, etc.)*
	support new devices [LPWAN / Wi-Fi] OR ☐ Engage a telecommunications provider to establish a new access plan for existing infrastructure that will support your new devices	We anticipate needing communications coverage in the following areas (e.g., suburbs): __________ [LPWAN / Wi-Fi only] We anticipate a need for [*insert number*] additional gateways.
IoT Platform (device hosting, management, and basic data interpretation)	☐ No action required (an existing option is available within Council) __________ OR Engage a new commercial solution for device hosting and management: ☐ Through your chosen device supplier OR ☐ Through a third party platform provider that is familiar with your preferred device option(s)	Name of platform that you plan to use:
Data management and storage	☐ No action required (an existing option is available within Council) OR (choose one): ☐ Investigate and set up a new cloud-based data storage solution to meet your needs	Details of existing or proposed data management and storage solution, if known: Provider**:** ☐ Cloud ☐ On-premises Who manages and integrates the service?

	Your action	Details if known *(e.g., specific technology, provider, etc.)*
	☐ Investigate and set up a new on-premises data storage solution to meet your needs ☐ Proprietary devices with data management and storage included ☐ IoT platform with storage included	☐ Council ☐ Device supplier ☐ Device management platform supplier ☐ Other:
Analytics and visualisation	☐ No action required (an existing option is available within Council) OR (choose one): ☐ Procure proprietary devices with analytics and visualisation included ☐ Procure an analytics/visualisation solution bundled into a new standalone IoT or data platform ☐ Procure a new standalone analytics/visualisation solution that integrates with your data platform	What functionalities do you need? *Check any that you think might apply* Analytics: ☐ Automated data quality control ☐ Heterogenous data modelling ☐ Environmental modelling ☐ Machine Learning / AI Visualisation: ☐ Custom/complex graphing ☐ Heat maps ☐ GIS integration ☐ Digital Twin integration Other:
		Details of existing or proposed analytics/visualisation solution, if known Provider: Name of platform:

	Your action	Details if known *(e.g., specific technology, provider, etc.)*
Data sharing	☐ No action required (an existing option is available within Council)	
	OR (Choose one): ☐ Procure a new private standalone data discovery portal/service/platform	*If known…* Provider: Name of platform:
	☐ Share data via an online open data portal	*If known…* Name of platform:

2. Platform quality requirements

When you consider procuring a platform or service there are several quality attributes that you can assess to support your decision. Work through the following table and select whether each requirement is a high, medium, or low priority for you. You can then use the result to support your procurement decision-making.

Please refer to Section 2 of *A guide to developing technical requirements*, in the section titled *Platform quality requirements*, where you will find detailed guidance relating to each of the platform quality criteria.

High priorities: essentially non-negotiable; without them, you would not be able to achieve your goals.
Medium priorities: things that are strongly favoured but can be worked around if need be; a slight compromise here would not be a showstopper.
Low priorities: nice-to-haves.

Quality criteria	Description	Our requirements
Integration	Integration refers to the ability of a platform or service to integrate with other platforms or services to form a large complete functional system that meets your needs.	Importance: ☐ High ☐ Medium ☐ Low
Interoperability	Interoperability refers to the ability of a platform or service to exchange data and integrate functionality via common shared language and protocols. It is closely related to integration (above) but is more sophisticated.	Importance: ☐ High ☐ Medium ☐ Low
Portability	Portability refers to the ability to migrate data or applications between two platforms or cloud service providers. Requirements. In this scenario, portability will be highly important.	Importance: ☐ High ☐ Medium ☐ Low
Hosting	Hosting refers to the ability of a platform or service to provide an environment that is able to host a diversity of sensing devices or discreet software modules.	Importance: ☐ High ☐ Medium ☐ Low
Supportability	The supportability of a platform or service relates to how well it can be configured and adapted to fit with the broader context of an organisation, and with the more specific context of a project or data use case.	Importance: ☐ High ☐ Medium ☐ Low
Security	Security refers to the ability of a system to detect and resist unwanted external interference or data access and applies at all levels of a technology stack.	Importance: ☐ High ☐ Medium ☐ Low

Quality criteria	Description	Our requirements
Auditability	Auditability refers to the ability of a platform or service to provide and maintain full traceability of user access and transactions.	Importance: ☐ High ☐ Medium ☐ Low
Scalability	Scalability refers to the capacity of a platform or service to scale-up or scale-down to meet changing needs.	Importance: ☐ High ☐ Medium ☐ Low
Availability	Availability refers to the amount of time that a platform or service is available to users and able to perform its expected functions	Importance: ☐ High ☐ Medium ☐ Low
Reliability	Reliability refers to the probability that the platform or service will do its job effectively across a defined period of time. Or put another way, reliability is a measure of the probability of system failure.	Importance: ☐ High ☐ Medium ☐ Low
Performance	Performance refers to the ability of a platform or service to support a series of context-specific needs – specifically relating to the amount of time required to undertake common functions and processes.	Importance: ☐ High ☐ Medium ☐ Low
Usability	Usability refers to how easy a platform or service is to use, including the overall look and feel of the interface and the user experience (UX) design.	Importance: ☐ High ☐ Medium ☐ Low

Quality criteria	Description	Our requirements
Reporting	Reporting refers to the ability of a platform to produce a report or visualisation based upon a custom user query.	Importance: ☐ High ☐ Medium ☐ Low
User support	User support refers to the collection of user-focused resources that may accompany a platform or service.	Importance: ☐ High ☐ Medium ☐ Low
Training	Training refers to the training materials (e.g., videos) and active support (training sessions, online or on-premises) provided to platform users.	Importance: ☐ High ☐ Medium ☐ Low

3. Platform hosting considerations

A platform must be hosted on a server, however there is a choice between cloud-based hosting and on-premises hosting. Which option is best for you?

Most commercial services are now cloud-based; however, this does not rule out on-premises hosting as an option. Indeed, many local governments already run on-premises servers that can host the types of platforms required for running a smart sensor network and some organisations favour the use of their own on-premises hosting capacity over the cloud. While a consensus is seeing an embrace of cloud-based solutions, which have improved greatly in functionality and reliability over the past decade, there are still pros and cons of both approaches that you may want to consider. A hybrid approach (combining both) is also a common option that can capture the advantages of both while minimising their disadvantages.

a) Your context

Existing on-premises hosting/storage capacity	☐ Yes (we have existing on-premises servers that could host platforms for this project)
	☐ No (we do not have any existing on-premises servers that could host platforms for this project)

Organisational policy	☐ Our organisation has no fixed policy on cloud vs on-premises hosting and data storage.
	☐ Our organisation does have a fixed policy on cloud vs on-premises hosting and data storage. We have reviewed it and understand what it means for this project.

b) *Your preference*

Our preferred platform hosting and data storage approach is	☐ Public cloud
	☐ Private cloud / On-premises
	☐ Hybrid *Details of preferred hybrid approach (if known):*

4. Data architecture modularity

A modular approach to data architecture involves keeping the various layers described above separate from and independent of each other. If you intend to use existing platforms and services, you will need to integrate them into a more extensive system and, this requires a more modular approach. However, just because you have existing platforms that can support your needs, it does not necessarily make sense for you to use them. You need to consider the pros and cons of taking a modular approach to determine if it is right for you.

Please refer to the *Modular data architecture decision-making tool* found in Section 2 of the *Guide to Developing Technical Requirements*. The tool explores the pros and cons of taking a modular approach compared to more off-the-shelf all-in-one commercial platforms and services.

Having considered the pros and cons of both approaches…

- ☐ We believe that a modular approach to data architecture is best suited to our needs.
- ☐ We believe that an all-in-one services approach to data architecture is best suited to our needs.
- ☐ We believe that a hybrid approach (modular/all-in-one) is best suited to our needs.

References

NSW Health. (2020). *Particulate matter (PM10 and PM2.5)*. NSW Government. https://www.health.nsw.gov.au/environment/air/Pages/particulate-matter.aspx

US EPA. (2022). *How to Use Air Sensors: Air Sensor Guidebook*. https://www.epa.gov/air-sensor-toolbox/how-use-air-sensors-air-sensor-guidebook

United States Environmental Protection Agency. (2022). *The Enhanced Air Sensor Guidebook*. https://www.epa.gov/air-sensor-toolbox/how-use-air-sensors-air-sensor-guidebook

Associated OPENAIR resources

Supplementary resources

A guide to developing technical requirements

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

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.

A framework for categorising air quality sensing devices

This resource presents a new framework for categorising air quality sensing devices in an Australian context. It identifies four tiers of device types, separated in terms of functionality, and the quality and usability of their data output. It is designed to assist with the selection of devices that are appropriate to meeting the needs of a project and an intended data use case.

Further information

For more information about this project, please contact:

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This supplementary resource 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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