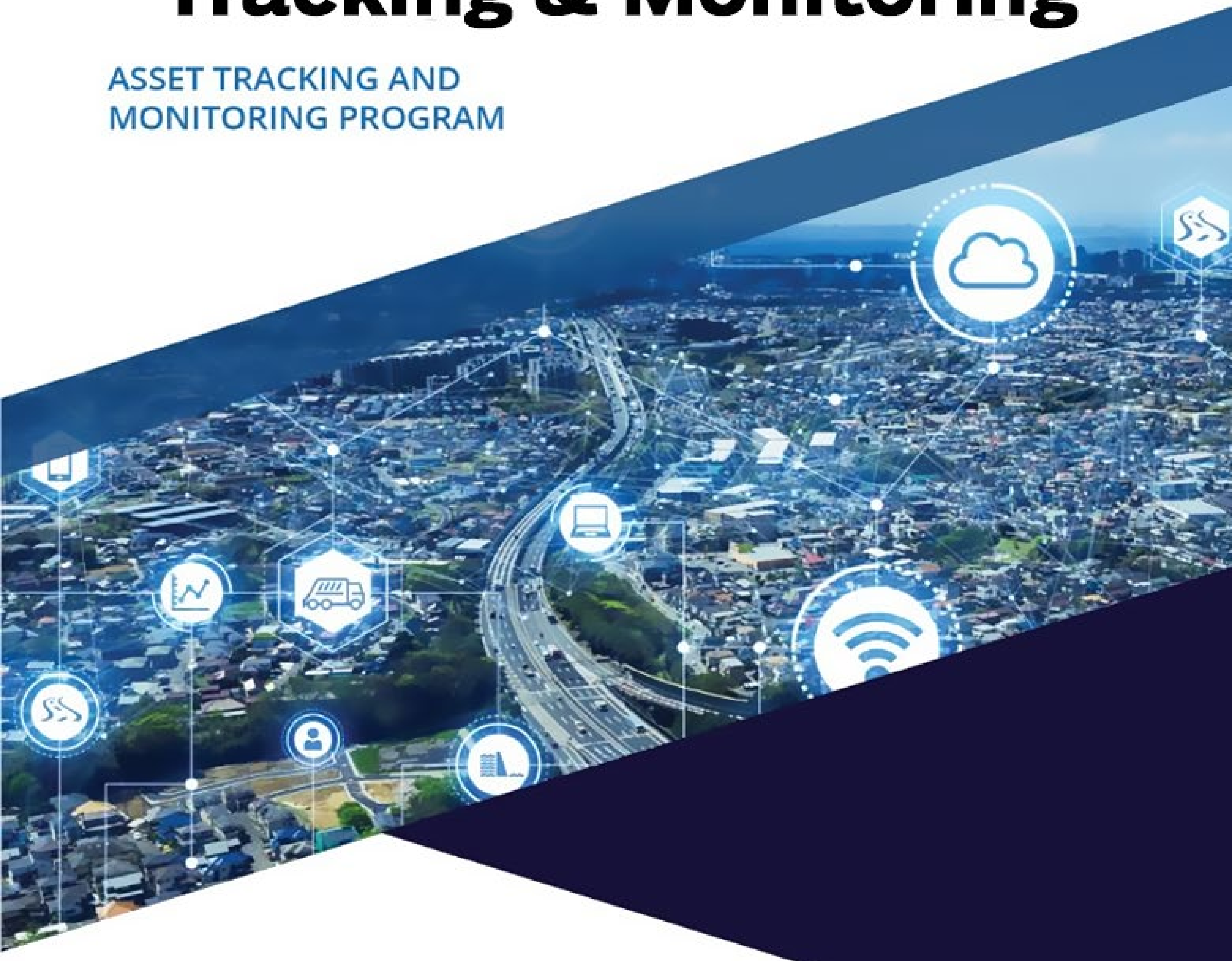
# The Business Case for Asset Tracking & Monitoring

## ASSET TRACKING AND MONITORING PROGRAM



EMERGING TECHNOLOGY BY IPWEA

## Source Acknowledgement

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## Document Information

# Acknowledgements

IPWEA acknowledges the intellectual and in-kind support of our corporate partners and members in delivering the Asset Tracking & Monitoring Program. The Program provides education and resources which assist our 4,000+ members make informed decisions about asset tracking and monitoring solutions and related deployments to enhance asset management. In addition to providing education and resources in this area, IPWEA works jointly with our partners in advocating for measures that increase the adoption of emerging technologies in a rapidly changing field.

IPWEA specifically thanks the following organisations, which encompass both communications network providers and, device and service providers, for their contributions to the development of IPWEA's Asset Tracking & Monitoring Program. They have variously engaged in discussions about the development of the program, participated in surveys, commented on draft documents and/or provided contributions of material for key documents and training materials.

| | | |
|---|---|---|
| **Actility** | **Intelematics** | **Optus** |
| **Azentro** | **IntelliTrac** | **Pivotel** |
| **Cody Corporation** | **Lacuna Space** | **Smartrak** |
| **Digital Matter** | **M2M Connectivity** | **Teletrac Navman** |
| **Eroad** | | **Telstra** |
| **Fleet Complete** | | **Thinxtra** |
| **Fleet Space Technologies** | **Movus / FitMachine** | **Netstar** |

# Contents

# Introduction

As the next development in our Emerging Technologies workstream, IPWEA has developed this document as a guide to the business case for deploying asset tracking and monitoring technologies. It is accompanied by a model specification to assist public buyers, vendors, contractors, financiers and advisors to navigate the process for considering investment in asset tracking and monitoring systems, and to efficiently and economically engage in procurement of these systems and bring tendering efficiency and certainty to the market.

The need for this document and training about the Business Case for Asset Tracking & Monitoring was identified in a 2020 review by IPWEA of the status of emerging technologies that had both demonstrably reached some commercial maturity and could provide material benefit to its members.

As with IPWEA's experience with its first Emerging Technology Program on Street Lighting & Smart Controls, stakeholders who were engaged in the development of this program noted fragmented approaches to asset tracking and monitoring procurement and deployment. While this pattern is typical of many new technology markets it suggests sub-optimal outcomes at a project-specific level and at a broader national level.

## Purpose and Target Audience

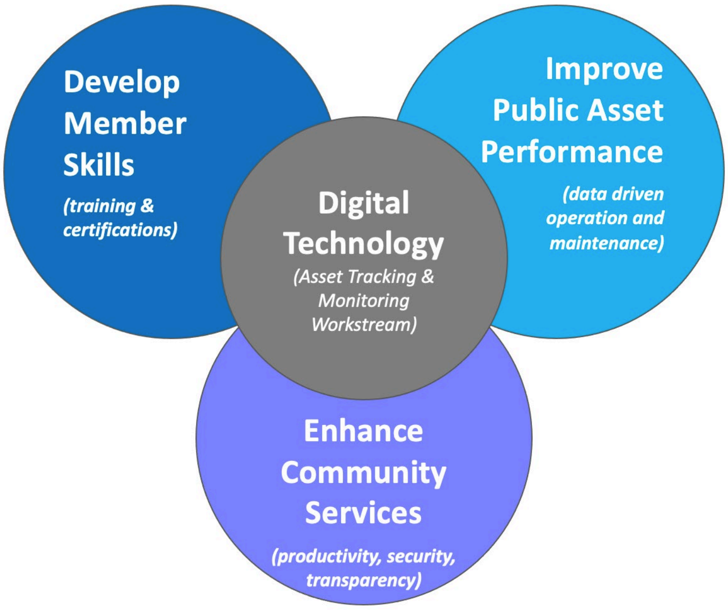
This document is targeted at IPWEA's members, professionals who deliver public works and engineering services to communities including those in all tiers of government as well as in the private sector. It is intended to help these professionals understand the relevant technologies and the benefits of their deployment to assist in the development of a robust case for investing in asset tracking and monitoring solutions. This in turn will encourage more pervasive adoption of these technologies within the relevant sectors and enhance the ability of organisations to best manage their assets and deliver better outcomes for the communities and stakeholders they serve.

A key objective of this document is to provide support for organisations that would like to move forward with their asset tracking and monitoring projects but lack the time, resources, or in-house expertise to do all the foundational work to inform the development of their business case.

Alongside the model technical specification for asset tracking and monitoring, this document about the business case should equip any professional to move toward a confident outcome in their asset management projects.

## How does 'The Business Case for Asset Tracking and Monitoring' fit within the IPWEA Emerging Technologies Asset Tracking and Monitoring workstream?

The IPWEA Asset Tracking & Monitoring workstream is designed to help our members to leverage appropriate digital technologies to manage assets more effectively. This in turn helps them develop their skills in applying digital technology to the asset management task and provides benefits in relation to the performance of the assets themselves as well as the community services they underpin.




The Asset Tracking and Monitoring workstream comprises the following elements:

- The Business Case for Asset Tracking & Monitoring *(this document)*
- Model Specification for Asset Tracking & Monitoring
- Online Learning Program (registration fee required) providing participants with the opportunity to:
  1. Increase their knowledge and understanding of Asset Tracking and Monitoring technologies and use cases;
  2. Access to tools and guidance materials to build a business case using inputs from their own organisation;
  3. Earn certification via a digital badge in Asset Tracking & Monitoring technology and its application to asset management;
  4. Access a Business Case Outline including an appendix providing a detailed survey of benefits of asset tracking and monitoring technology which will help members to develop business cases for applying asset tracking and monitoring technology in their own organisations; and
  5. Access an Excel-based 'Returnable Schedule' to assist in a procurement process.

## The Business Case for Asset Tracking and Monitoring – Summary of Contents

The Business Case for Asset Tracking & Monitoring provides guidance to help members understand asset tracking and monitoring technologies and how to apply them to managing assets.

The document starts with Scope & Context in the first section. This includes high level information about what asset tracking and monitoring is, including an introduction to its constituent technologies and some examples of these. It goes on to cover the origins and development of asset tracking and monitoring as well as its future growth trajectory. The Scope & Context section then clarifies which sectors and assets are in scope - Fleet Assets, Portable Equipment & Supplies, Stationary Plant, Fixed Infrastructure and Access Infrastructure and provides an assessment of the state of the asset tracking and monitoring market. A final subsection provides links to additional resources for further reading.

The second section of this document provides an Overview of Technologies, starting with a high-level overview of the constituent technologies (Devices, Communications Networks and Central Management Systems) and then coverage in more detail on each of these key constituent elements. Section 2 then goes on to cover: Asset Tracking & Monitoring Devices, delineating between the different devices for different asset types; Communications networks used in asset tracking and monitoring; and, Central Management Systems.

The third section of this document provides links to a range of Case Studies from our supplier's survey demonstrating how asset tracking and monitoring has been deployed across the various asset types in scope. This gives readers the opportunity to see real world examples of the benefits of asset tracking and monitoring.

In the fourth and final section of this document, there is an introduction to Developing a Business Case with a focus on providing a practical set of steps to guide the user in developing their own business case to be used in concert with the materials provided through the online learning program to inform, educate, persuade and empower members and their organisations to develop their own business cases.

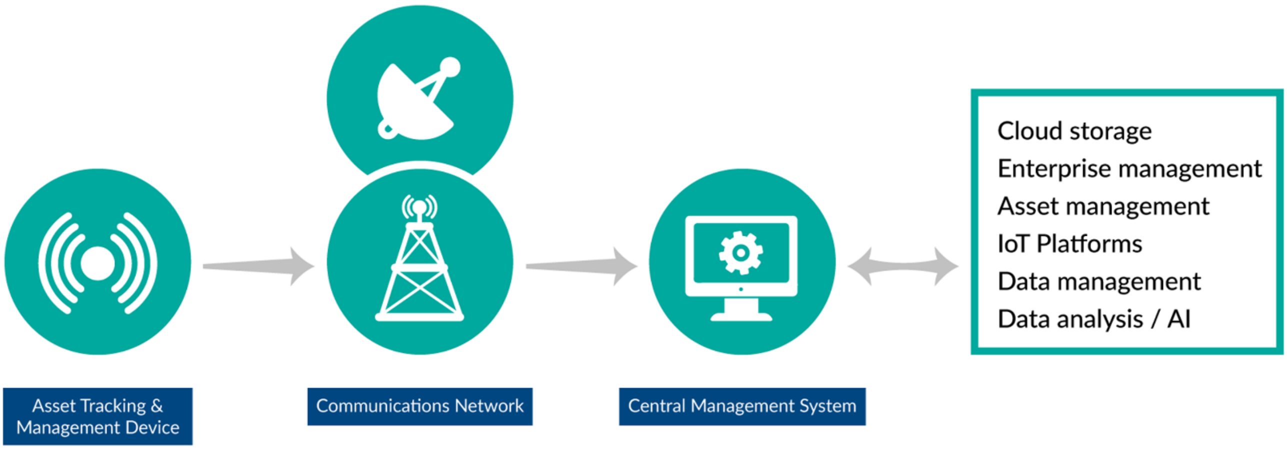
IPWEA believes this document and the other elements of the Asset Tracking & Monitoring workstream will serve our members well into the future. We thank you for your interest and support and look forward to assisting you with your asset tracking and monitoring requirements.

# 1 | Scope and Context

## 1.1 What is Asset Tracking & Monitoring?

Asset tracking and monitoring is the combination of three constituent technologies: an asset tracking and/or monitoring device, a communications network and a central management system. When deployed together as a system, they can enhance an organisation's ability to ensure that its assets remain completely functional and perform at optimal levels throughout their lifecycle.

### Essential Elements of Asset Tracking & Monitoring




### Asset Management and Asset Tracking & Monitoring

Asset tracking and monitoring involves a wide array of communications and sensing technologies but, at its core, it is fundamentally about good asset management so that communities can be better served.

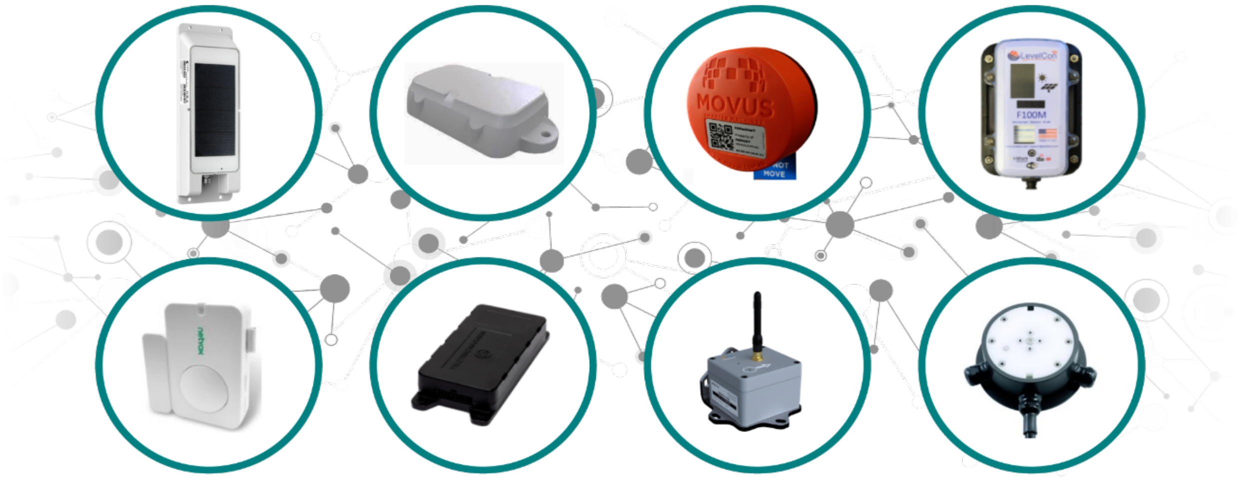
While it is important to understand the capabilities of the technologies and how best to apply them, it is key to note that the technologies discussed in this document are simply the means of delivering better outcomes.

With rapid advances in technology as well as declining costs, asset tracking and monitoring can be successfully applied to a growing range of public works infrastructure. Examples might include monitoring:

*Asset tracking and monitoring's primary purpose is to deliver better outcomes for our communities.*

- whether a key water pump is working properly;
- whether vibration patterns on a bridge are abnormal;
- what stresses a section of pavement is being subjected to;
- whether an electrical substation door is ajar;
- how many hours an engine has run since its last service; or
- where key vehicles or pieces of equipment are located.

### Examples of Asset Tracking & Monitoring Devices




When properly applied, good asset tracking and monitoring can deliver benefits such as:

- improved asset utilisation;
- optimised maintenance cycles;
- rapid identification of public safety risks; and
- alerts about possible faults, breakage, theft, and vandalism.

Asset tracking and monitoring should therefore be an important element of the asset management strategy of any asset-intensive organisation because it can cost-effectively use digital technology to provide accurate, relevant, and granular information about the organisation's assets. Real-time, near real-time or regularly updated asset location and condition data (to suit the asset) can be monitored and assessed to allow organisations to make data-driven decisions about their assets to improve the services that they provide to their communities.

Asset tracking and monitoring is an evolving set of technologies and is playing an increasing role in how services are delivered. With any new technologies, there are inevitably a few hurdles and challenges to overcome but they are not insurmountable. The uptake of asset tracking and monitoring technology thus far has been somewhat fragmented despite its potential to contribute enormous value to good asset management.

This guide and the accompanying Model Specification are intended to establish asset tracking and monitoring as part of the asset management system in any public works or asset intensive entity. They can help do this by supporting sensible adoption of these technologies by IPWEA's members and stakeholders to help better the communities that they serve.

## Development of Asset Tracking & Monitoring Technology

### Evolution of Asset Tracking & Monitoring


The idea of applying technology to enhance asset management is not new. In the 1970s, manual written recording of asset information with pen and paper began to be replaced with automatic identification systems, initially in the form of barcode technology inherited from the retail and logistics sectors. In the public sector, many assets were labelled with a barcode label, typically made of a durable material (such as aluminium) due to the long life of public sector assets, often in a harsh environment.

The barcode is a symbolic representation of data, usually an identification number for the asset, which helps reduce human errors caused in counting and transcription. Typically, a barcode scanning device with onboard data storage would allow the barcode labels on assets to be scanned and then batch uploaded to a computer which would then allow the data to be entered into a spreadsheet.

During the 1980's, software programs which enabled the data to be scanned directly into appropriate fields in a database and allowed the user to enter additional details, became prevalent. The scanning devices also evolved to include a user interface allowing the user to enter additional details as well as capture date and time at the point of scanning. As computer networking proliferated, the data could be transmitted to other computers on the network which enabled information to be easily shared and moved to where it was needed.


In the 1990's wider application of early Wi-Fi technology, which had been used in niche industries like warehouse management, allowed data about assets to be sent wirelessly within a local site. This facilitated real-time data capture and allowed this data to be instantly available within a monitoring and management system. In addition, RFID (Radio-frequency identification) technology emerged.

RFID required fixed readers for reading tags on assets moving past the reader location or portable readers carried by a user to a fixed asset. Centralised software systems also became more prevalent allowing data to be integrated from the field, to be stored centrally and to be analysed in new ways. The internet also brought the ability to collect, store and share the information captured in real-time across disparate locations and provided more advanced visualisation and calculation capability more easily.

In the 2000's advancements in ancillary technologies including the advent of wireless wide area networks and cloud computing, enabled asset tracking and monitoring technology to provide point-of-activity data to inform decisions across the organisation. Other wireless technologies such as Bluetooth and open standard Wi-Fi emerged as options for communicating data.

Finally, in the past decade, the advent of the Internet-of-Things (IoT) negated the need to have a person capturing the data at the asset location, allowing live data from the asset to be transmitted to a central management system. Concurrently, smaller and lower-cost computer chips and sensors as well as low power wide area wireless networks (LPWANs) emerged to support the varying needs of asset management use cases. The IoT, smaller and lower cost computing/sensing chips and LPWAN's were the final pieces of the puzzle, allowing billions of assets globally to be easily and effectively tracked and monitored.

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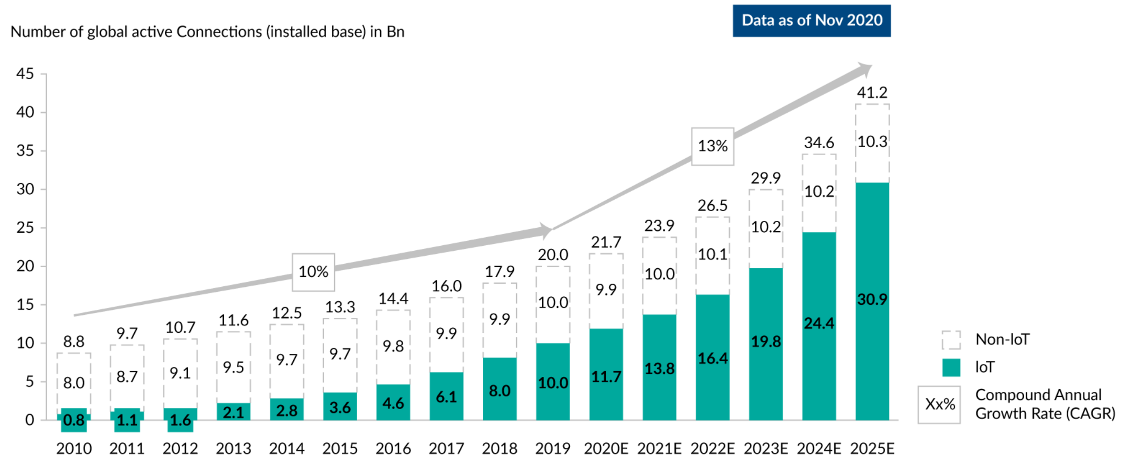
The cumulative effect of these simultaneous technical advances is that there is an extensive array of cost-effective and efficient indoor and outdoor location tracking and monitoring technologies available for most asset management use cases.

At a high level, today's cloud based IoT solutions have also removed the need for expensive IT infrastructure and reduced operating costs. They can easily be deployed in small quantities and massively scaled up over time to support huge portfolios of assets providing a very significant return-on-investment at all scales.

## Total Number of Device Connections (incl. Non-IoT)

20.0Bn in 2019- expected to grow 13% to 41.2Bn in 2025




Note: Non-IoT includes all mobile phones, tablets, PCs, laptops, and fixed line phones. IoT includes all consumer and B2B devices connected - see IoT break-down for further details

Source(s): IoT Analytics - Cellular IoT & LPWA Connectivity Market Tracker 2010-25

While you may not be aware of it in your work yet, the impact of these changes is amply demonstrated in the growth of devices connected to the IoT. As per the chart below, the number of connected IoT devices now exceeds that of non-IoT devices and the growth rates of IoT devices are high and continuing to accelerate. By 2025, the number of connected IoT devices is expected to top 30 billion and be three times as many as all the mobile phones, tablets, personal computers (PC's), laptops and fixed line phones in the world combined.

Concurrent with this growth are rising community expectations about the public services delivered by public assets necessitating ever higher levels of asset management capability that can only be successfully delivered through technology.

What's next? Emerging technologies such as data analytics, artificial intelligence (AI) and machine learning (ML) are further contributing to the value of asset tracking and monitoring. They offer the potential to derive more insights from the data collected and drive far better decisions about assets that can transform an organisation and the way it conducts itself and delivers value for its community stakeholders.

## Sectors & Asset Types

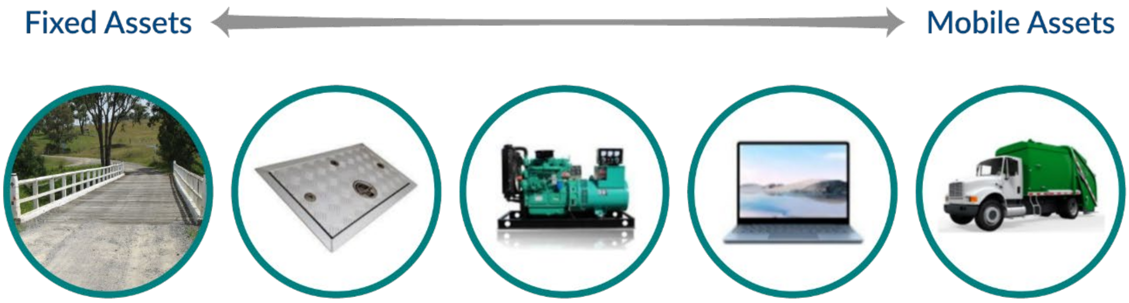
This document focusses on public domain assets which are designed, built and operated for the purpose of facilitating public sector services and are the most common asset types across all levels of government and amongst private sector players delivering similar services.

For the purposes of this document and given the significant breadth of assets which relate to asset tracking and monitoring in this sector, these assets have been divided into five broad types. These types have been selected because the features required for asset tracking and monitoring are generally similar within each group.

**Table 1: Asset Types**

| Asset Type | Typical Examples |
|---|---|
| **1. Fleet** | Waste/recycling vehicles, other mobile plant / vehicles (e.g., street sweepers, excavators, graders and elevated platforms), passenger cars and light commercial vehicles |
| **2. Portable Equipment & Supplies** | Laptops, handheld electronic equipment, emergency equipment, safety equipment, lawnmowers, pressure washers, portable generators, specialist tools & other park/public domain maintenance equipment, pallets of supplies etc. |
| **3. Stationary Plant** | Static equipment such as pumps, generators, boilers and cogeneration |
| **4. Access Infrastructure** | Doors, gates, access hatches (and the keys that access them) and stormwater covers |
| **5. Fixed Infrastructure** | Pavements, bridges, retaining walls, sea walls, dams, stormwater infrastructure |

In general, the asset types above are distinguished by the degree to which they are fixed in one location for their asset life or mobile.




This document covers general asset tracking and monitoring tasks for the types of common public sector assets listed above. Highly specialised IoT devices in areas such as building management systems, lighting controls, smart parking and utility metering are not specifically encompassed in the scope of this document or in the related model specification. While closely related, these types of devices typically provide a much wider range of functionality specific to their application and, as such, require more specialised consideration and specifications.

## 1.2 Status of the Market and Deployments

Asset tracking and monitoring technology covers a wide range of public domain assets as described in Section 1.1 above. Overall, the deployment of asset tracking and monitoring technology has been fragmented in the Australasian context, particularly in the public sector.

With the possible exception of fleet telematics, there are few examples of use cases which have high levels of penetration in any market segment. Thus far, deployments in the public sector have been mostly *ad hoc* in response to government grants or the particular interests of staff. Rarely have they created impetus for scale across related or adjacent functions within the organisation or between different organisations.

The vast bulk of non-financial assets by all levels of government is fixed infrastructure. In Australia, for example, there is $1.5 trillion in fixed infrastructure assets managed by the three levels of Australian governments (30 June 2020 estimate of current replacement cost).

*Governments in Australia manage more than $1.5tn in assets.*

In recent years, many local governments have adopted fleet telematics (the remote monitoring of vehicle location and other parameters) as their first foray into asset tracking and monitoring. However, many other types of mobile assets and most fixed infrastructure is currently unmonitored except for periodic checks by engineering and other staff based on risk. These inspections, while they may be conducted by highly experienced engineers, are generally visual, external and largely qualitative in nature.

In mid-2021, IPWEA surveyed its members and other stakeholders about their use of fleet telematics systems. The anonymous survey was issued as an Electronic Direct Mail (EDM) using email and received well over a hundred responses with 65% from local govt, 6% from state govt and the rest from other sectors. Key findings of the survey are included in Section 2. The survey validated the wider uptake of fleet telematics by local government and other stakeholders than other types of asset tracking and monitoring.

The state of the market for other types of asset tracking and monitoring is attributable to a range of factors including:

1. **Customer confusion and hesitancy** created by:
    - A lack of understanding of the business case for adoption
    - A lack of understanding of the technology
    - The wide range of asset tracking and monitoring use cases, technologies and, in some cases, technical immaturity
    - The large number of suppliers and small average supplier size
    - Lack of standards, particularly with respect to asset tracking and monitoring devices and central management systems
2. **Internal customer limitations** due to:
    - Public sector risk aversion
    - Silos between ICT (Information & Communications Technology) departments and operational business units
    - Constrained funding and committed operational expenditure budgets
    - Organisational culture, skills and resources
3. **Challenges for suppliers created by the wide variance in local contexts necessitating highly segmented market offerings**

Despite the challenges of the market, IPWEA's assessment is that the business case for asset tracking and monitoring is strong in many areas and getting stronger due to progressively declining costs, increasing capability and increasing supplier maturity. This gives IPWEA confidence that asset tracking and monitoring technology can and should be more widely adopted as this document seeks to demonstrate.

## 1.3 Review of Resources

In providing the below list of resources, it is worth noting that during the planning and market engagement phase of IPWEA's Asset Tracking and Monitoring program, as well as in the development of this document, two key observations were made about information resources.

Firstly, a distinct lack of independent sources of information was noted. The vast majority of publicly available asset tracking and monitoring information is provided by private sector suppliers. Though some of these provide good general and relatively non-proprietary context that is of value, the commercial focus of the authoring entity makes them potentially less trusted and valuable to IPWEA's members.

Secondly, asset management resources, in general, lack any significant detail and often any mention at all about asset tracking and monitoring technology. These two observations serve to underscore the importance of this document and this program in raising the profile of asset tracking and monitoring technologies and accelerating their deployment.

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Since 2020, IPWEA has published the following articles on Asset Tracking & Monitoring:

1. How to use asset tracking to improve infrastructure maintenance
2. Making your dollar go further: Why asset tracking is critical in an economic downturn
3. Unlocking the benefits of asset tracking in your workplace
4. Using technology and the IoT to improve asset performance
5. Automated asset tracking technology saving time and money

The following are other publicly available resources that provide information that asset management professionals will find useful as supplementary reading materials:

1. Track and Monitor Asset Loss White Paper | Telstra Nov 2019
2. Types of asset tracking technologies | Deloitte
3. How can asset tracking bring value for you? | Deloitte
4. How to create a powerful business case for investing in asset tracking | GoCodes
5. Creating the Business Case for Investing in Asset Tracking | GoCodes
6. Asset Tracking Done Right: Benefits, Tools, Strategy | Limble CMMS
7. Fleet Management for Local Government | Teletrac Navman
8. The Cost Savings of Telematics Whitepaper | Smartrak
9. Asset Theft on the Rise Whitepaper | Smartrak
10. Are NB-IoT and LoRA really competing for the same market? | Plextek
11. State of the IoT 2020: 12 billion IoT connections, surpassing non-IoT for the first time | IoT Analytics

# 2 | Overview of Technologies

## 2.1 Introduction to the Elements of Asset Tracking & Monitoring

The three core elements which comprise an asset tracking and monitoring system are:

### 1) Asset Tracking and Monitoring Devices

Asset tracking and monitoring devices are designed to attach to and/or integrate with an asset and collect data relating to relevant parameters which are essential for the proper functioning of the asset. For example, optimising the management of a mobile asset such as a vehicle typically involves collecting location data.

### 2) A Communications Network

A communications network enables the data captured by the device to be transmitted from the location it is captured to a Central Management System. The network which is used must be appropriate for the use case. The appropriate network can be determined by the location and environment within which the device operates, the nature and volume of the data being sent, and the timeframe within which the data is required to be received by the Central Management System.

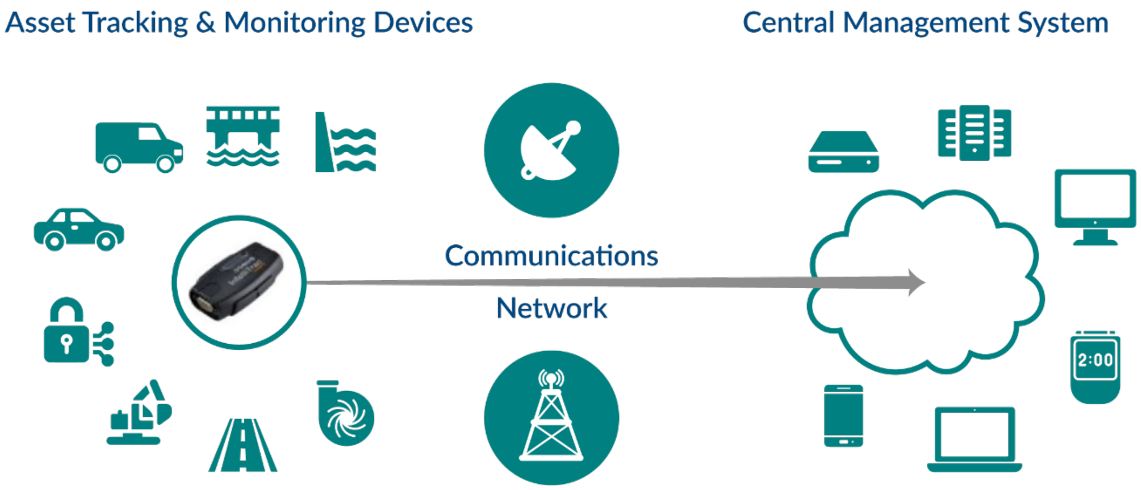
### 3) A Central Management System

A Central Management System is software which is hosted on-site or, increasingly, in the cloud. It captures the data collected by the asset tracking and monitoring device transmitted via the communications network and uses the data in various ways to enable users to perform a range of functions that facilitate monitoring and management of the asset. These functions are performed via a user interface on a computer, tablet or smart phone and typically include visualisation, reporting, alerting, diagnostic analysis, benchmarking etc.

> **The Internet of Things (IoT)**
>
> *Asset tracking and monitoring technology is a subset of the Internet of Things (IoT). The IoT describes the network of physical objects, so known as, "things" — that are embedded with sensors, software, and other technologies that are used for the purpose of connecting and exchanging data with other devices and systems over the Internet.*

For the purposes of this document, we have not considered other systems and technologies which may be used to supplement or support an asset tracking and monitoring system or which it may need to integrate with. These could relate to cloud storage, Enterprise Resource Planning (ERP), IoT Platforms, Communications Management, Asset Management, Document Management or Content Management, Data Management, Data Analytics, Data Exchange Platforms, Open Data Portals, Machine Learning (ML), Artificial Intelligence (AI), Virtual/Augmented Reality (AR/VR) and others.

While these systems all potentially have a role in integrating information from asset tracking and monitoring systems into the organisation's information systems and providing extended and enhanced benefits beyond those of the asset tracking and monitoring system, these are intentionally not in scope for this document (though aspects of integrating with these systems are addressed in the accompanying model specification).




## 2.2 Asset Tracking & Monitoring Devices

This section describes the basic elements of asset tracking and measuring devices and then illustrates how these elements are configured for the most common use cases. Importantly, this section (and the document more broadly) are focused on devices that can be deployed by the customer rather than those devices embedded in equipment at the time of manufacturing.

### Asset Tracking & Monitoring Device Elements

Asset tracking and monitoring devices must bring together several physical elements to successfully provide the desired functionality:

1) A suitable **enclosure** designed to house the components in a manner that robustly protects it from failure (e.g., with an IP rating suitable for the environment, vibration resistance, resistance to radio interference), a shape and size that suits the application and a design approach that allows it to be quickly and securely installed.
2) A **power supply** which may either be a long-life battery or an external connection to a power source.
3) One or more sensors for the measurement of parameters such as:
    a. Asset position (GPS – Global Positioning System or other global navigation satellite system) which is most relevant for fleet and other portable assets; and
    b. Operational data such as fuel efficiency, engine temperature, operating hours, acceleration and speed for fleet telematics systems whilst for other types of asset tracking and monitoring sensors may measure parameters such as ambient temperature (and other climate parameters), vibration, tilt, tension, pressure, noise, water levels, water flow or traffic movements.

   Note that while today's asset tracking and monitoring devices are primarily sensors, devices are expected to increasingly have the ability to accept and implement commands from the Central Management System. This might involve something as simple as an alarm activation or more complex commands that change the actual settings on the device being monitored in some way (e.g., a temperature sensor may activate a control to slow or shut down a system if it detects its operation is out of range, a location sensor might initiate an intervention to limit or cut off power to an engine if it detects it operating outside of a geo-fence).

4) **Communications** components allowing data transmission via at least one communications network. In many cases, communications are two-way, allowing sensors data to be transmitted as well as allowing the Central Management System to send instructions and firmware upgrades to sensors.

### 2.2.1 Fleet Telematics Devices

**Use Case Overview**

Asset tracking and monitoring devices designed for vehicle fleets, usually called fleet telematics, can be used in the full range of fleet assets from cars to trucks to the many types of specialist vehicles used by public sector service providers.

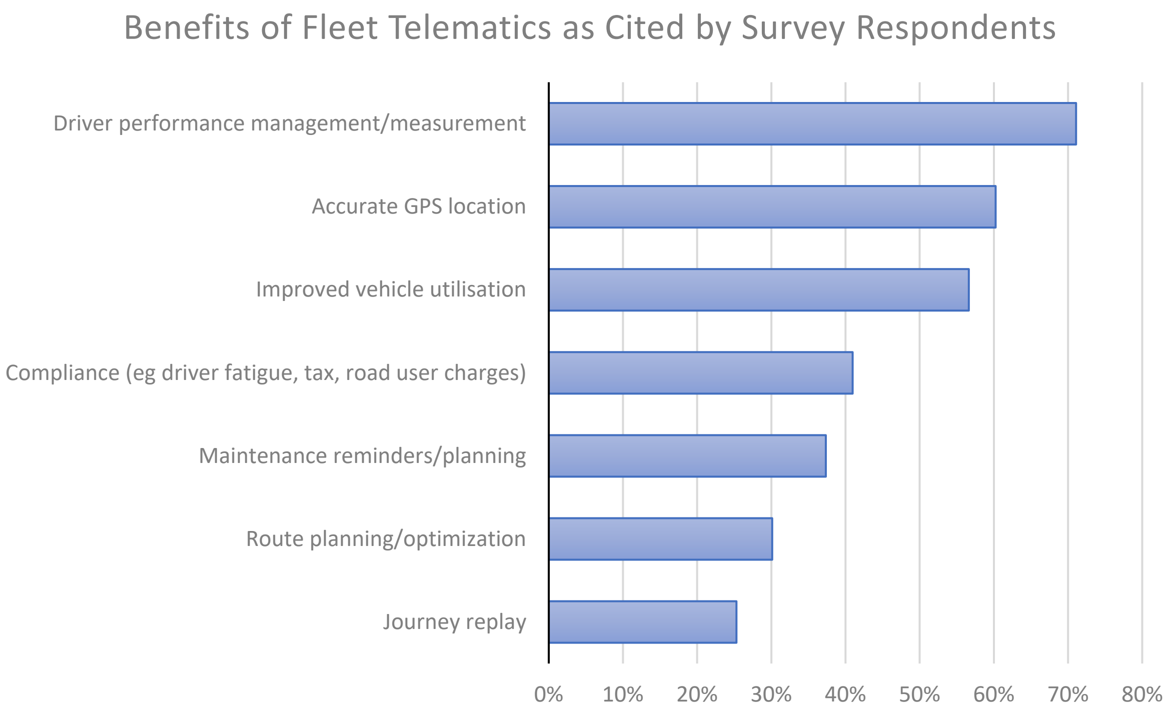

Fleet telematics devices track the location of vehicles, monitor fuel efficiency, monitor indicators of unsafe driving and can offer remote diagnostics and many other features.

Fleet assets are generally of moderate to high value, with significant operating and maintenance costs and fulfil important community services which need to be executed in a timely manner either in response to some event or in alignment with a fixed schedule. Fleet telematics help asset owners to get the best value from these important assets. Fleet use cases differ from most other asset tracking and monitoring categories in that the asset is driven or operated by a person when it is in use.

**IPWEA Member & Stakeholder Survey Insights**

In mid-2021, IPWEA surveyed its members and other stakeholders about their use of fleet telematics systems. The anonymous survey was issued as an Electronic Direct Mail (EDM) to stakeholders and received well over a hundred responses with 65% from local government, 6% from state government and the rest from other sectors. Key findings of the survey were as follows:

- Deployments of fleet telematics by our members started more than a decade ago with 64% of survey respondents having implemented or currently implementing fleet telematics. Deployments appeared to be growing steadily in pre-pandemic years.
- 43% of survey respondents are tracking 50 vehicles or less suggesting that many organisations are tracking only selected portions of their fleet. However, 26% of respondents are tracking 200-500+ vehicles suggesting some members are already tracking most or all of their fleet.
- While a 1–2-year payback was the most common estimate of survey respondents whose organisations had assessed the payback of fleet telematics, there was a wide distribution of estimated paybacks. This likely reflected the different fleet types that the systems were applied to and whether the full capabilities of these systems were implemented (Suppliers have consistently reported to IPWEA that many fleet telematics users are not implementing the full range of capabilities that these systems deliver). Notably, 58% of survey respondents were uncertain about the payback period of their systems.
- As per the graph below, more than half of survey respondents report the same three top benefits of fleet telematics of: 1) driver performance management; 2) accurate GPS location; and 3) improved vehicle utilisation.




**Form-Factor**

Fleet tracking devices generally mount inside the vehicle cab and/or engine compartment. The device is within a robust case and built to be shock and vibration resistant. While fleet tracking devices do not necessarily have the highest levels of moisture Ingress Protection (if being installed in cabs and engine compartments), protection from dust ingress is a key issue in vehicles. The size of the device is not critical for fleet tracking devices but cannot be so large as to make it difficult to mount in cabs and engine compartments.

**Connection & Installation**

Most fleet tracking devices are installed by the specialist providers of fleet tracking services in a secure manner, with testing to ensure that they are fully functioning at the time of installation and in a manner that mitigates theft of or tampering with the device.

Some devices are offered as plug and play devices, enabling the vehicle driver, fleet manager or a non-technical staff member to install the device. The advantage of a self-installed fleet tracking devices is reduced down-time and reduced cost by not needing a professional installer. However, caution must be used to ensure that the operating environment, vehicle type and use case are appropriate for this option. The risk of tampering or theft can be somewhat mitigated by a disconnect alert function common with such systems.

Devices can be installed almost anywhere on a fleet vehicle but are usually installed via an on-board diagnostics (OBD) port. The OBD port is typically located near the steering wheel close to the driver's knees. OBD ports were originally designed to allow mechanics to run diagnostic reports and interface with the vehicle's onboard computer. However, as OBD standards have evolved, commonly supported approaches, such as the OBD II standard, provide a wide variety of data to fleet telematics devices in a consistent manner across a range of vehicle types from different manufacturers. If the asset doesn't have an OBD port, some suppliers offer a hardwired connector to the vehicle electrical system but have limited functionality as a consequence.

**Parameter Measurement**
Fleet assets ideally require tracking and monitoring of a range of parameters. OBD ports are ideal because they facilitate real-time information collection of a wide range of measures. The parameters which are measured by or calculated by fleet telematics devices can include:

- vehicle position (GPS - Global Positioning System)
- distances travelled
- fuel consumption and fuel levels
- engine RPM
- engine temperature
- engine faults
- airflow
- braking and cornering
- speed, acceleration and deceleration
- concerning driver behaviour such as speeding, aggressive braking, excessive idling time, over-revving, and excessive driving hours

Some fleet telematics providers have, in recent years, extended their fleet offerings to also encompass lone-worker tracking. The workplace health and safety implications of lone workers driving to distant sites and working there alone are well recognised as an issue, particularly in organisations serving large rural areas. While not directly a fleet tracking offering, this interesting adjunct offering may merit consideration for some organisations as part of a fleet telematics procurement process.

Not all fleet tracking devices are the same in terms of the parameters they measure, and the fleet tracking device requirements need to be aligned to the specific requirements of the use case, operating environment and business process.

**Communications**
Fleet tracking devices generally need to have two ways to facilitate external communications.

Firstly, vehicle location being very useful, if not critical, in all fleet asset use cases means that line of site to GPS satellites is required.

Secondly, a suitable communications interface to transmit data to the CMS is required. The communications network used for fleet tracking devices needs to be suited to frequent data transmission to ensure vehicle location is updated with sufficient granularity. The volume of data in fleet use cases is also relatively high compared to other use cases so the available bandwidth provided by the communications network needs to be appropriate to allow the various parameters to be transmitted to the CMS.

Finally, the extent of mobility with fleet assets means the communications network coverage is important within the area of operation of the fleet asset. And, given the movement of vehicles, the network needs to be capable of smooth handoff from one gateway to another at speed while continuing to transmit data.

In practice, the need for widespread coverage, relatively high bandwidth and the capability to handoff to different gateways while moving at speed means that most fleet telematics systems use one of the mobile phone networks (with satellite-based systems being increasingly useful for remote locations). Refer to Section 2.3 for more information on communications networks.

## 2.2.2 Devices for Portable Equipment & Supplies

**Use Case Overview**

Even a modestly sized council can have many dozens of sites with its portable equipment and supplies dispersed across these sites and moving frequently between them and to other locations in the public domain. Such assets can include things like laptops, specialist handheld electronic equipment, emergency equipment, safety equipment, lawnmowers, pressure washers, portable generators, specialist tools & other park/public domain maintenance equipment, pallets of supplies etc. While these assets generally have lower value than fleet assets, new smaller and lower cost asset tracking technologies make them increasingly worth tracking.

**Portable Equipment with Sensor**

The motivations for tracking such portable equipment and supplies are varied and include:

- Assisting with readily locating assets that may be used or stored across dozens of possible sites;
- Assisting in emergency situations to locate critical pieces of equipment or supplies;
- Reducing theft and loss through misplacement;
- Minimising the unnecessary purchase of additional assets because current stock is hard to locate (of particular reference to specialist equipment and tools); and/or
- Assisting in tracking the number of assets of a particular type or supplies of a particular type (eg pallets of specialist pavers, spare street furniture, spare equipment).

**Form-Factor**

Asset tracking devices for portable equipment and supplies generally need to be smaller than for fleet applications, given the size of most of these kinds of assets. Encasement, vibration / shock resistance and IP ratings within this category vary widely, depending on the asset and the environment in which it is used. However, given the outdoor nature of most public works and assets, requiring a highly robust enclosure would be the norm for most of our members.

**Connection & Installation**

Asset tracking devices for portable equipment and supplies must be suitable for secure and robust attachment to or integration within the asset. This is not always straightforward, given the widely varying types of assets that such devices might be attached to and the harsh environments that many of them are found in. A device that can be easily knocked off (or easily removed by a thief, for example) is not going to serve the intended purpose.

Unlike fleet, asset tracking devices for portable equipment generally need to be battery powered since the asset does not usually have its own easily accessible electrical power source. Battery life is a material issue for such assets which tend to be set-up to communicate only the most essential information and at a frequency that is no more than necessary to keep power consumption as low as possible. Battery lives can vary from a few months to as many as 10 years depending on the requirements of the device and how the user sets it up.

**Parameter Measurement**

Generally, for devices tracking portable equipment and supplies, location is still useful but does not need to be captured with the same level of frequency, granularity or accuracy as for a fleet asset. The cost of continual GPS location may be prohibitive and the impact on battery life is significant, therefore suppliers have often found ways to infer location from other data or approximate it via triangulation on the network being used for communications.

There are currently few, if any, devices which measure additional metrics in terms of performance of the relevant asset. This is due to a desire keep the cost of devices as economical as possible, given the generally lower value of the asset.

**Communications**

A wide range of communications networks could be used for tracking portable equipment and supplies. The location where they are used may be, to some extent, less predictable than for fleet so the network availability may require storage of data on the device until network connection is re-established. The bandwidth required is much smaller due to the limited parameters being measured and the frequency with which data needs to be transmitted is lower.

Beyond the common IoT communications networks, it is worth noting that RFID remains a relevant technology for some lower value assets. For example, if extensive stores are maintained across multiple sites, RFID tags may be a particularly cost-effective solution to track stock and its movement.

### 2.2.3 Devices for Stationary Plant

**Use Case Overview**

Stationary plant, such as pumps, boilers, cogeneration, generators, motors, compressors and fans can be critical pieces of equipment, of high value and are typically designed for long duty cycles. While some are general purpose, many are essential to the proper functioning of large public facilities, and some are absolutely critical to the operation of those facilities (including in emergency situations).


**Stationary Plant Sensor**

Stationary plant, by definition, is rarely moved and typically designed for deployment at a fixed location. Within this category of asset tracking and monitoring, the emphasis is therefore almost entirely on the monitoring. For stationary plant, this is usually termed Condition Monitoring.

Condition monitoring involves monitoring one or more key parameters of a piece of equipment, such as temperature or vibration, in order to identify significant changes which may indicate that a fault is developing or, more simply, to signal that maintenance is needed. Condition monitoring systems play a valuable role in helping organisations avoid surprise breakdowns, plan maintenance optimally, reduce downtime and cut overall costs. In simple terms, they change the maintenance management of these key pieces of equipment from being reactive or planned (where the 'planned' cycle may have little to do with the state of the equipment) to being condition-based and driven by real-time data. Overall, they bring confidence that key pieces of equipment are performing as required to help deliver important community services across organisations that often service a large geographical area and operate many sites.

**Form-Factor**
The form factor of condition monitoring devices is less critical in terms of size for stationary plant. However, ingress protection, in terms of dust and water as well as resistance to mechanical impact is important to ensure that the device is able to operate within the often-harsh environment of a plant room.

**Connection & Installation**
Condition monitoring devices must be suitable for secure and robust attachment to or integration with the asset. Bolted, adhesive or magnetic mounting systems are offered by different suppliers to suit the application. Unlike portable assets, the asset is typically electrically powered via direct connection to the grid or via on-site generation, so battery power may not be required except for when reticulated power is not ideal or as backup in the event of a power outage. A more challenging issue is that stationary plant is often located in areas which naturally make access difficult or restricted.

**Parameter Measurement**
Condition monitoring devices are typically designed to measure parameters which provide predictive information on performance to ensure that the asset continues operating at optimal levels. The most commonly monitored parameters are:

- Vibration
- Temperature (e.g., of casings, oil, exhaust)
- Noise (both audible and ultrasonic)
- Electricity or fuel consumption
- Electrical or mechanical output

Of particular importance in recent years is the growing role of data analytics, machine learning and artificial intelligence systems in not just monitoring such parameters but in interpreting the data coming out of condition monitoring sensors. It is this predictive intelligence that can alert managers to subtle changes in data patterns and help them understand the overall condition of each asset, help schedule maintenance and alert them to impending faults.

**Communications**
Stationary plant is mostly found in buildings meaning that condition monitoring systems can often use wired networks or Wi-Fi networks if the appropriate infrastructure exists at the facility. Given that stationary plant is typically located within buildings, sometimes deep within a structure, the use of radio-based networks can sometimes be more challenging. Where critical infrastructure is involved, the security features of available networks are very important.

## 2.2.4 Devices for Access Infrastructure

**Use Case Overview**

Wired security access systems for buildings using key cards, security dongles, touchpads and biometric recognition scanners are a relatively mature and widely deployed set of access technologies. However, these systems are relatively costly to implement and, in situations where there is not readily available power and communications infrastructure, the costs of deploying them has been prohibitive and greatly limited their deployment.


**Door/Window Sensor**

The advent of the IoT, miniaturisation of sensors and the ability of these sensors to function for years on a single battery has opened up the opportunity to cost-effectively monitor a much wider array of remote access infrastructure. This includes doors (and even the keys that open them), remote gates, access hatches to mechanical / electrical / communications enclosures and windows as well as public domain infrastructure like stormwater covers.

Monitoring of access infrastructure can provide real time or near-real time information (and alarms) about whether a door, gate, hatch or stormwater cover has been opened or moved. In doing this, these devices can reduce the risk of accidents and detect unauthorised intrusion in even relatively isolated locations without any existing electrical or communications infrastructure.

**Stormwater Cover Sensor**

**Form-Factor**

The form factor for most access infrastructure monitoring devices is generally quite small (as small as a few centimetres in some cases). These devices need to be able to be securely attached to the asset in such a way that it measures opening and closing or movement consistently and without risk from tampering.

As with other similar devices to be placed outdoors, ingress protection levels need to be high in terms of both protecting against both dust and water. The device also needs to be highly resistant to shock given the forces to which the device is exposed in repetitive opening and closing.

**Stormwater Cover Sensor**

**Connection & Installation**

Devices must be securely attached to the asset in a manner that allows measurement or opening and closing action and/or control of locking mechanisms or movement. While traditional access infrastructure has generally been wired to existing power and communications systems in buildings, the types of emerging IoT access monitoring devices covered by this document are generally battery powered.

**Parameter Measurement**

Access monitoring devices are mostly focused on sensing the opening and closing of an asset or its movement. The approach taken varies widely but generally, is based on sensors that detect changes in proximity (using ultrasound, light, infrared or electromagnetic fields) or detect vibration/movement or detect changes in tilt/orientation.

In some cases, access monitoring devices also track additional parameters (e.g. some stormwater sensors can also measure the prevailing water level below the cover, some hatch sensors can detect rain).

**Communications**
The amount of data collected and transmitted by access control devices may be minimal compared to many of the other types of sensors discussed in this document. They are thus able to work on even the lowest bandwidth networks and such networks may be most suitable in that the power required for transmission may be minimal which conserves battery life. In a further effort to conserve battery power, transmission from such devices may be solely event-based (e.g. when a gate is opened outside of normal hours or when the movement of a stormwater cover is detected).

### 2.2.5 Devices for Fixed Infrastructure

**Use Case Overview**
The vast bulk of non-financial assets by all levels of government is fixed infrastructure. In Australia, for example, there is $1.5 trillion in fixed infrastructure assets managed by the three levels of Australian governments (30 June 2020 estimate of current replacement cost).

**Rural Bridge**

The Australian and New Zealand inventory of fixed infrastructure includes:

- more than 1.4 million kilometres of paved and unpaved roads
- more than 50,000 bridges and many other types of transport infrastructure
- thousands of kilometres of retaining walls and sea walls
- more than 5,000 dams, weirs and barrages
- a wide array of water and stormwater infrastructure
- tens of thousands of buildings and other public structures

These fixed infrastructure assets play vital, sometimes critical, roles in our communities. At present, most fixed infrastructure is inspected periodically based on risk. These inspections, while they may be conducted by highly experienced engineers, are generally visual, external and largely qualitative in nature.

As with other categories of asset tracking and monitoring, the advent of the IoT, miniaturisation of sensors and the ability of these sensors to function for years on a single battery has opened up the opportunity to cost-effectively monitor a much wider array of the fixed infrastructure summarised above.

Monitoring of fixed infrastructure can provide real time or near-real time information about fixed infrastructure but, perhaps more usefully, provides long-term data that can increasingly be analysed by artificial intelligence to detect subtle changes in key parameters over time.

Sensors for fixed infrastructure can monitor parameters such as vibration, tilt, tension, pressure, temperature, water levels, water flow and traffic movements. In monitoring these parameters and using techniques like artificial intelligence, asset owners can identify assets that should be prioritised for detailed inspection, that should be at the top of the list for renovation or replacement and, in the extreme, that may be at risk of failure. In short, these systems allow them to make data-based decisions about asset management. This is now possible even in relatively isolated locations without any existing electrical or communications infrastructure because of the combination of [Internet of Things] (IoT) communication networks, miniaturisation of sensors and clever sensor design that facilitates long battery life.

**Form-Factor**
The form factor for most fixed infrastructure monitoring devices is generally quite small (as small as a few centimetres in some cases). As with other similar devices to be placed outdoors, ingress protection levels need to be high in terms of both protecting against both dust and water.


**Infrastructure Monitoring Sensor**

**Connection & Installation**
Devices for monitoring fixed infrastructure need to be able to be securely attached to the asset in such a way that it allows for accurate measurement of the parameters being monitored. However, they also need to be in a location that allows for consistent radio transmission. On large concrete and steel structures or inside a pipe or facility of some type, this can sometimes be an issue.

**Parameter Measurement**
As noted above, sensors on fixed infrastructure can monitor a wide variety of parameters (e.g. vibration, tilt, tension, pressure, temperature, water levels, water flow and traffic movements). While the range of parameters that might be monitored is quite broad, one distinguishing characteristic with fixed infrastructure is the increased focus on monitoring long-term trends in the data generated.

**Communications**
The amount of data collected and transmitted by fixed infrastructure sensors may be relatively small compared to many of the other types of sensors discussed in this document. Many are thus able to work on even the lowest bandwidth networks and such networks may be most suitable in that the power required for transmission may be minimal which conserves battery life. In a further effort to conserve battery power, transmission from such devices may be relatively infrequent (e.g. daily) or solely event-based (e.g. when a certain threshold is reached).

## 2.3 Communications Networks

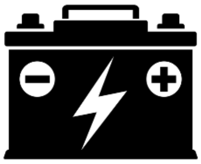
### 2.3.1 Network Characteristics

Communications networks used for asset tracking and monitoring vary widely because of the wide array of assets, nuances in use cases and deployment contexts. At a high-level, networks differ on the basis of a number of key characteristics which make them appropriate for some applications and not for others:

- **Bandwidth** – Bandwidth is the maximum data rate at which the network can transmit data (upload/send and download/receive). Bandwidth needs to be higher if more data needs to be transmitted more frequently. Generally, more mobile use cases like fleet applications would require more bandwidth than other use cases like fixed assets which typically don’t need to communicate often or send much data when they do.

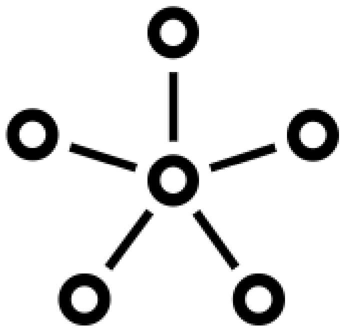
- **Latency** – Latency is the delay with which data is transmitted by the network as a result of any factor relating to how the network is designed and how it functions. For some assets, knowing about an event to the minute, second or milli-second might be vital (e.g., the failure of a critical piece of mechanical or electrical equipment). For other types of assets, reporting once a day may be entirely acceptable (e.g. a temperature sensor reporting daily highs and lows).

- **Power Utilisation** – The power drain on the device attributable to the connection to the network and transmission of data via the network. Wireless connections consume far more power than wired connections which is important when a device is battery powered and installed in a remote location where regular battery replacement is impractical and/or commercially unviable. The most effective asset tracking and monitoring devices include sophisticated power management features to reduce power drain.

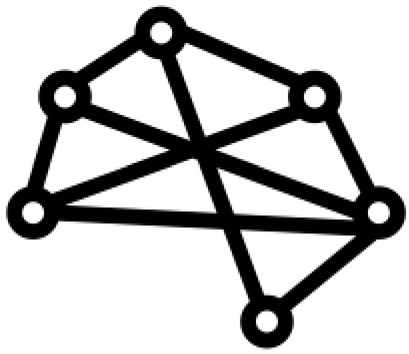


- **Range** – The distances a network can transmit data between transmission/receiving points and devices in the field is important when the asset is located at some distance from the nearest gateway. An organisation managing assets in disparate and remote rural locations will need to consider range much more carefully than in an urban area.

- **Topology** – The type of network topology defines the arrangement of elements in a network and the way that data is transmitted between devices and gateways. Some networks are only able transmit from a gateway directly with each device in the field (a star network) while others are able to have signals hop from one device to the next (a mesh network). Network topology can impact on the cost of the network and transmission distances as well as the varying ability of the network to provide capabilities such as *self-healing* where the failure of one gateway can be mitigated by data being transmitted along alternative gateways.



**Star Network Topology**



**Mesh Network Topology**

- **Coverage** – The coverage of a network is the geographic area it serves. The extent of signal propagation from a gateway is important when assets are located some distance from the nearest gateways, but topography may also affect different network types in different ways. Where a fully managed network service is required, pre-existing coverage is an important consideration.
- **Handoff** – The capability of a network to manage the transfer of communications from one gateway to another at speed is called handoff. This is critical for mobile assets where data transmission must be possible whilst the asset is moving while being “handed over” from one gateway to another.

- **Scalability** – The maximum number of devices per gateway can be an important issue when there are large numbers of separate assets concentrated in specific locations requiring a high number of concurrent connections to each gateway.

- **Security** – Network security measures are a vital aspect of all IoT networks. Different networks offer different levels of security and each organisation will have its own security requirements. While detailed discussion of this issue is beyond the scope of this document, the following references may be useful:

  - Securing the Internet of Things for Consumers – Code of Practice, Australian Government
  - Cyber Security for Consumer Internet of Things: Baseline Requirements, European Telecommunications Standards Institute
  - Internet of Things Security Guideline, IoT Alliance Australia

- **Environmental Factors** – Extraneous factors can affect network performance. For example, a network which requires line of sight may be an issue in mountainous terrain, amongst tall buildings or where coverage is required within buildings.

- **Network Management** – Some networks offer varying degrees of network management capability both in terms of automated diagnostic, alerting and repair capabilities, as well as automated deployment capabilities where large fleets of assets can be remotely and automatically activated or de-activated, and manual management services such as device staging.

- **Operating Model** – The network operating model can be more or less practical for a specific use case. Client installed, owned and managed models require the client to purchase, install and manage the network. Provider installed, owned and managed networks are a fully managed service where the client does not need to be involved in the network elements at all. The scale of the deployment, the size of the area within which the assets operate and the willingness of the organisation to manage a network are all important considerations here.

- **Gateway Portability** – The practical ability to move gateway locations, if required, may be a requirement for some asset use cases. For instance, where portable assets are deployed into a location with no pre-existing network for a period of time and then are moved to another location also requiring a network. Typically moving gateway locations for LPWAN networks, for instance is not overly arduous whilst doing so for cellular networks is.

For further overall discussion of asset tracking and monitoring networks, their characteristics and selection considerations, see the following references:

- IoT Platform Selection Guideline, IoT Alliance Australia
- IoT Reference Framework – Application Guide, IoT Alliance Australia
- IoT Reference Framework, IoT Alliance Australia
- Types of Asset Tracking Technologies, Deloitte

## 2.3.2 Overview of Asset Tracking and Monitoring Networks

There are many communications networks which could be used for asset tracking and monitoring applications. This guide focusses on the four most common network types used in Australasia which are as follows:

| IoT Communications Network Type | Approximate Share of Global LPWA Connections[1] |
|---|---|
| 1. Mobile Networks | 47% (NB-IoT and CAT M) |
| 2. LoRaWAN Networks | 41% |
| 3. Sigfox Networks | 7% |
| 4. Satellite Networks | Perhaps 1-2% |

### Mobile Networks

Mobile networks include the various categories of services available from cellular telecommunications providers. These originated as networks for mobile phones but have since expanded to cater for data and varying related use cases.

Mobile networks use licensed spectrum which the network operator purchases from the relevant telecommunications authority (ACMA in Australia and Radio Spectrum Management in New Zealand).

Mobile networks have been through multiple generations of development with 3G (3rd Generation) coming to the end of its life and being discontinued in 2023 in Australia, for example. The focus in this document is on 4G which is underpinned by a set of technology standards called Long Term Evolution (LTE).

In general, mobile networks have a number of advantages for asset tracking and monitoring:

- Existing networks with no need for customers to install gateways or manage networks
- Widespread coverage, particularly in urbanised areas
- Use of exclusive licensed spectrum with high levels of security and low levels of interference
- High bandwidth
- Low latency

### About 5G

*5G (5th generation) technology networks were launched in 2018/19 and are designed for advanced use cases which, for the most part, are yet to emerge. 5G is capable of much higher bandwidth and lower latency than required for most asset tracking and monitoring use cases and hence, is not widely used for such applications yet. However, 5G may be covered in future updates as this next generation of technology begins to dominate all facets of the market.*

[1] IoT Analytics, Global LPWA Technologies (2020 to 2025)

- Massive scalability to handle a very large number of IoT devices
- Very high handoff capabilities for mobile assets

The main disadvantages of mobile networks for asset tracking and monitoring are:

- Generally higher on-going costs than other IoT communications networks
- Power usage is generally higher than with other IoT networks and hence, much less suitable for battery-powered devices (though new variants like NB-IoT seek to address this)
- Coverage in rural areas can be poor with individual customers having little ability to influence the placement of gateways (e.g. mobile towers)

There are many variants of LTE with different data speeds, frequency spectrum, power usage and signal range. The three of greatest relevance to asset tracking and monitoring are summarised in the table below. Each of these three variants are offered by Telstra, Optus and Vodafone in Australia while Vodafone NZ offers them in New Zealand.

| **CAT NB1**<br>(also referred to as NB-IoT) | **CAT M1**<br>(also referred to as CAT M) | **CAT 1** |
|---|---|---|
| NB-IoT is the newest variant of LTE and is designed for simple devices with very low bandwidth, less frequent communication, and lower power needs. It is the category of LTE most directly comparable to other IoT networks like LoRaWAN and Sigfox. | Long-Term Evolution (LTE) for Machines (LTE-M) is also known as Cat M or Cat M1. Cat M supports low power wide area use cases with lower device complexity and extended coverage, while allowing the reuse of the LTE installed base. Cat M also designed to support battery-powered devices. | CAT 1 has been the variant of 4G that has, thus far, supported asset tracking on most fleet assets and other similar use cases. CAT 1 is a widely available and mature technology with more than enough bandwidth to handle applications like fleet tracking. |
| **PROS**<br>• Better coverage than CAT 1 and CAT M1<br>• Works well indoors and in dense urban settings<br>• Relatively fast response times for a LPWAN<br>• Sleep and power saving modes mean lower power use for battery-powered devices | **PROS**<br>• Slightly less costly than CAT 1<br>• Sleep and power saving modes mean lower power use for battery-powered devices<br>• Greater range than CAT 1 | **PROS**<br>• Higher bandwidth than NB-IoT and Cat M1 (Up to 10 MB/s)<br>• Lower latency<br>• Able to cross national boundaries |
| **CONS**<br>• Not suited to larger data volumes or speeds<br>• Can be difficult to implement firmware upgrades over-the-air<br>• Cannot handoff | **CONS**<br>• Lower bandwidth than M1 | **CONS**<br>• Slightly more costly than NB-IoT and M1 |
| 28 kbps down / 68 kbps up | 1 Mbps down / 1 Mbps up | 10 Mbps down / 8 Mbps up |
| 1.5 - 10s latency | 10 - 15ms latency | 50 - 100ms latency |

### LoRaWAN

LoRaWAN is a specification for an IoT network designed to wirelessly connect battery operated devices (which require low power utilisation) to the internet in wide area applications. The specification is developed and maintained by the LoRa Alliance which is an open association of collaborating members.

The underlying LoRa technology is a radiofrequency signal technology owned by US company, Semtech. They are the only chipset manufacturer or license holder for LoRa. The specification for LoRaWAN defines the technical implementation of the approach but allows the industry to innovate in terms of commercial models and use cases. Unlike mobile networks, LoRaWAN uses unlicensed spectrum.

If you want to use a LoRaWAN network you often need to deploy your own network gateways. However, a few markets in Europe have LoRaWAN network operators that 3rd parties can sign-up to connect to. Similarly, Spark and KotahiNet in New Zealand and NNNCo in Australia have deployed LoRaWAN networks covering large percentages of the population and allowing 3rd party connections without the need for each user to deploy gateways. Other firms, such as Meshed in Australia, are building substantial LoRaWAN networks for particular customers including a number of large local governments.

Pros of LoRaWAN are:

- Ability to set up and manage your own network where relevant
- Works well for mobile assets on the move
- Longer battery life for devices (better than NB-IoT or CAT M1)
- Potentially lower cost than mobile network variants
- Wide array of 3rd party devices available

Cons of LoRaWAN are:

- Lower data rates than NB-IoT
- Longer latency than NB-IoT
- Less coverage than mobile networks and therefore may require the customer to manage gateways
- Less advanced features than NB-IoT in some areas like routing, multicast and firmware broadcast
- Greater potential to interfere with each other when more than one is operator in an area

### Sigfox

Sigfox was the first company to highlight the potential for many types of IoT devices to be connected with a very low bandwidth network.

Sigfox is the most basic of the IoT network technologies and therefore has the lowest cost radio modules and generally, some of the lowest connections costs.

Sigfox uses an ultra-narrow portion of unlicensed spectrum. The technical approach used is particularly good at passing through solid objects.

In general, Sigfox licenses its technology to a local network operator which deploys a public network that customers can sign up to connect to. Customer therefore do not usually have to build or manage gateways. The network operator in Australia and New Zealand is Thinxtra which claims coverage of 83% of the Australian population and 94% of the New Zealand population (as of 2021).

Pros of Sigfox are:

- Lower connection costs
- Low power consumption (long batter life for devices)
- Good for devices that transmit small amounts of data infrequently
- Good coverage where located (see Thinxtra)

Cons of Sigfox are:

- Less coverage than mobile networks
- Limited bi-directional capability
- Can be difficult to implement firmware upgrades over-the-air
- Mobile assets not suitable

### Satellite Networks

Satellite networks are an important option in Australasia, given the geographical size of the countries and therefore the need to address remote regional and rural applications.

Satellite networks offer data as well as voice capability which is particularly useful where there are no other good options because other networks do not provide coverage, where the terrain would make other networks difficult to deploy and operate effectively, and where commercial considerations make other networks unviable.

The increasing prevalence of small, low earth orbit satellites and lower launch costs have substantially increased competition and lowered the costs of connecting an asset tracking device to a satellite. There are now a number of satellite providers in the Australasian region, each with their own offering including Fleet Space Technologies, Lacuna Space and Myriota.

Pros of satellite are:

- Coverage without terrestrial equipment
- Complete coverage footprint including in difficult terrain and the most remote locations
- Suited to isolated assets, critical infrastructure and emergency applications where network equipment failure or tampering is a risk
- Can be used for locating assets in combination with other networks - see GPS (Global Positioning Syetem/GNSS (Global Navigation Satellite System)

Cons of satellite are:

- Cannot be used indoors as line of sight required
- More expensive than other IoT network options
- Low bandwidth

### GPS Positioning Data

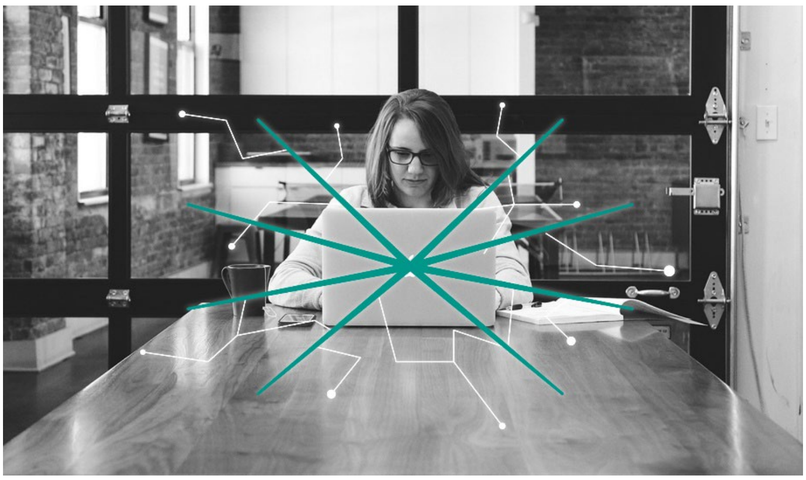
*Signals from specialised global navigation satellite systems like the Global Positioning System (GPS) can be used to provide geo-location data on assets in combination with other IoT networks that allow transmission of data both to and from an asset tracking and monitoring device. GPS location data is extremely accurate, near-real time and operates worldwide continuously in any weather, and at any time.*

### Other Networks

A number of other communication networks are available to connect asset tracking and monitoring devices. This includes networks more suitable for indoor applications (e.g. Wi-Fi, Li-Fi, Bluetooth, BLE, Zigbee, RFID, NFC) and a variety of niche, specialised and emerging network options (e.g. Wirepas, RPMA, DMR). All have a potentially useful role depending on the use case and scale of deployment. However, the primary communication network choices identified above represent the vast bulk of those currently being used for asset tracking and monitoring.

## 2.4 Central Management Systems

For the purposes of this document, dedicated Central Management Systems (CMS) are considered. In the asset tracking and monitoring market, the CMS is generally provided by the device/service provider.



As previously discussed, CMS may link to other data storage, data analytics, Enterprise Resource Planning, Smart City, IoT platform or other systems. These higher-level systems are not specifically addressed in this document, although some of the perspectives may apply.

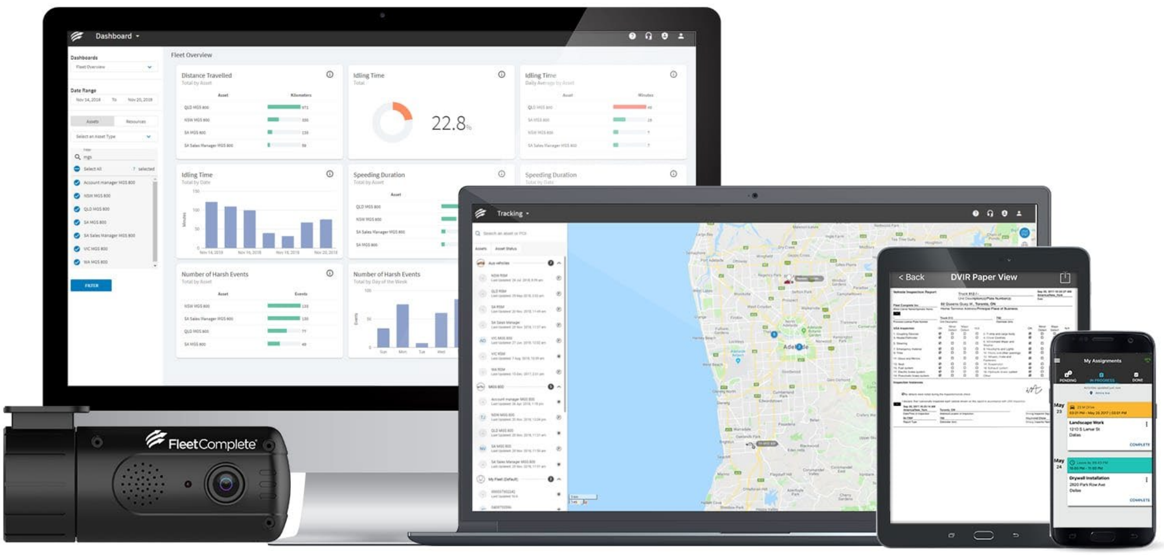
In asset tracking and monitoring use cases, the CMS is software which receives data from asset tracking and monitoring devices that has been sent via the communications network. The CMS, which is often hosted in the cloud as a service by the provider, uses the data from the devices to perform a number of functions via a user interface on a computer, tablet or smart phone.

As per previous parts of Section 2, this data might include GPS data as well as operational data from a fleet telematics system (e.g. fuel efficiency, engine temperature, operating hours, acceleration) or a wide range of parameters from other types of asset tracking and monitoring systems (e.g. ambient temperature (and other climate parameters), vibration, tilt, tension, pressure, noise or water levels, water flow and traffic movements).

## CMS Features & Functions

**Visualisation**

One of the primary functions of a CMS is to provide visualisations of the data to enable the user to interpret what may be very large volumes of data. These usually focus on the most important aspects of the assets' condition and performance. Visualisations are usually two dimensional and use the most common graphing formats such as maps, bar charts, pie charts and dials. Colours are often used to allow rapid assessment of whether the data represents an acceptable state (e.g. where green, amber and red are most common for obvious reasons).




Three-dimensional visualisation such as Digital Twins are emerging as an enhanced way of visualising the location, status and performance of an asset. These 3D visualisations are generally an augmented virtual reality representation of the asset and/or site at which the asset is deployed. 3D visualisation allows for more complexity to be represented and interpreted.

**User Interface**

The User Interface of a CMS is the way information is presented and how the software guides the user through the various functions on offer and tasks which can be completed. A simple and effective user interface is critical in making the overall system easy to use. This is important because the system only delivers value if it is used easily and used intensively. A "clunky" user interface can mean users won't use well it or will avoid using it. Some advanced CMS allow for a significant degree of customisation of both the user interface and visualisations within it, allowing the user to customise the look and content on their dashboard.

**Alerting**

CMS' usually offer the ability to set thresholds for nominated parameters and configure alerts which are triggered when those thresholds are met or exceeded. These might be alerts for an unresponsive sensor, a temperature sensor on an engine rising above a pre-set threshold, a hatch being opened in the middle of the night when is shouldn't be, rapidly rising water levels in a drain or a piece of equipment suddenly tilting over.

Alerts can be via a range of mechanisms including a visual notification, an audible notification or alarm and even a text message or email to nominated devices or users. Alerting provides the opportunity for an issue to be addressed before it escalates to a more significant level. Many systems offer escalating levels of alerting in response to either new data that indicates an increase in the severity of an incident or an alert being unresolved beyond a threshold period of time.

**Reporting**

CMS' core functions include reporting to allow scheduled or on demand reporting of the data based on the requirements of different supervisory users.

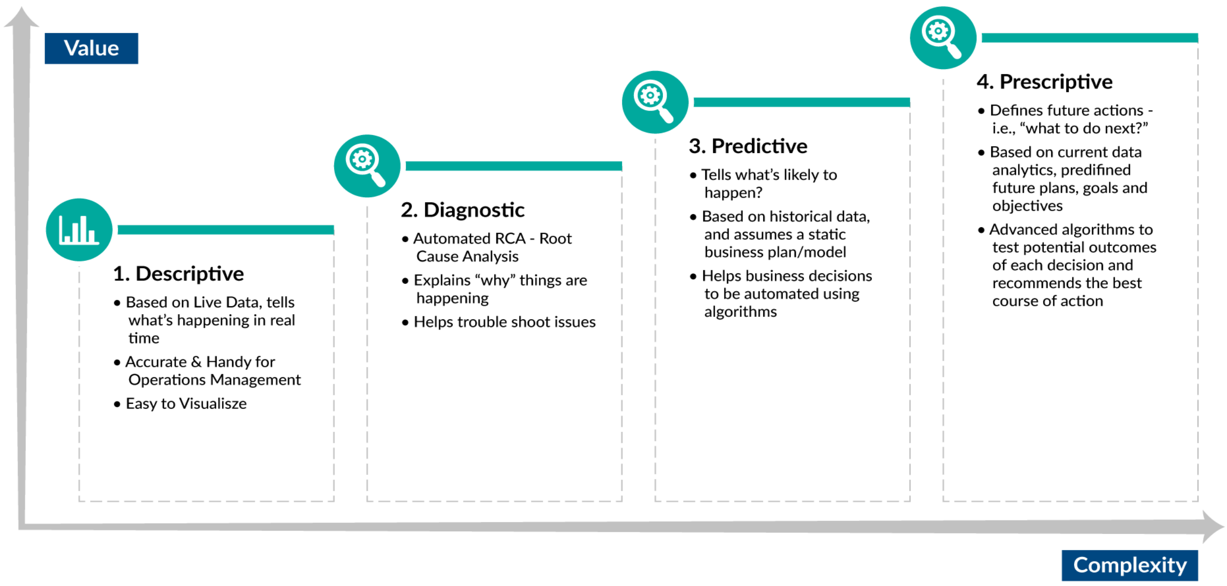
In most cases, large volumes of raw data from a network of sensors are utterly meaningless without analytics (see next item) and summary reporting. The capability of a CMS system's reporting aspects is thus incredibly important to how effectively a system can be used to deliver value for an organisation. Report formats can often be configured and changed as required to suit an organisation's needs.

**Analytics**

CMS' may provide some analytical capabilities to allow the user to see trends, readily identify exceptions and diagnose other issues highlighted by the data. Analytics capabilities of CMS's are usually fairly basic, and are limited to mostly one or two of the four categories of analytics shown in the graphic below:

- **Descriptive Analytics** which process the raw data from asset tracking and monitoring devices and potentially other sources to give valuable insights that describe what has happened. Insights are typically focussed on identifying that something is wrong and describing what is wrong.
- **Diagnostic Analytics** which also focusses on the past but is about identifying the reasons why something happened.

## Analytic Functions of CMSs




*Source: 4 Types of Data Analytics Every Analyst Should Know – Descriptive, Diagnostic, Predictive and Prescriptive, Co-learning Lounge, 2021*

Edge computing is a recent trend which involves pushing some processing and intelligence to the asset tracking and monitoring device itself where this is of value. This is also commonly known as "embedded AI" and may help take analytics to the level of being predictive and prescriptive.

**Hosting**

Any software, including a CMS, needs to be hosted somewhere – this just means the physical location where the database and software case are stored. Traditionally, software would be hosted "on premises", but the advent of cloud computing provides alternative ways of hosting software which may offer advantages in terms of overall cost, security from hacking or intrusion, and redundancy from physical damage, flood or fire which an on-premises server can be subject to.

One particular hosting consideration for public sector organisations is whether there are any requirements to host certain types of data (particularly where they related to personal information or critical systems) within the country. This is generally called Data Sovereignty (or sometimes Native Hosting).

There are sometimes complex trade-offs involved in selecting an appropriate hosting option and an organisation will usually need to align with its IT Policy and architecture.

**Customisability**

Most CMS's are fairly standard "off-the-shelf" offerings because asset tracking and monitoring systems are designed to be suitable for fairly narrow sets of use cases. For example, a CMS designed by a provider which targets fleet use cases would generally be designed around that sole use case. The CMS being focussed on a narrow set of closely related use cases means it can be fairly standardised and yet meet the needs of most of the target segment quite well. However, the nature of a specific use case may warrant considering the degree to which the CMS can be customised by the provider. In general, best practise involves limiting the amount of customisation for any individual customer to avoid high expenses and risks associated with obsolescence when a system is largely bespoke.

As noted above, CMS's do often provide configurability to allow the user to configure way the CMS functions and what it displays so that it can be adapted for some differences in their situation. Ideally this configurability should be in the hands of the user instead of requiring the provider to make changes which involves delays and costs.

**Compatibility**
Ensuring the CMS is compatible with the other IT systems which need to be used in conjunction with it is important. For example, the web browser or the computer operating system. Organisational IT policy and architecture have an obvious role to play here.

**Delivery Model**
Software has historically been purchased on a licensed basis with the organisation purchasing a license for each user or group of users. Increasingly, particularly as applications move to being hosted in the cloud, software for asset tracking and monitoring systems is purchased as "software-as-a-service" with the vendor being responsible for all facets of its operation, security, upgrades and backups.

**Integration**
CMS systems need to be able to send data to other systems and retrieve data from other systems. In the case of asset tracking & monitoring this might include cloud storage, enterprise resource planning, IoT platforms, asset management, document or content management, data management, data analytics, data exchange, open data, machine learning (ML), artificial intelligence (AI), virtual/augmented reality (AR/VR) and other systems. Other examples could be executive dashboards or business intelligence systems which ingest data from across the organisation to better understand, plan and execute business functions and decisions. Such integration is done via one or more Application Program Interfaces (API's) which provide a common language of sorts to use to transmit and interpret data between systems. Ensuring the CMS has API's which are published and open to third party organisations and systems to facilitate this is crucial. Organisational IT policy and architecture will again have a key role to play here in setting integration requirements.

**Maintenance - Updates and Upgrades**
A CMS can only be as good as the extent to which it is kept updated with the latest version. Versions may be updated to address security issues, fix bugs and issues in the software or upgrade functionality. The user organisation will want certainty around accessing these updates and upgrades.

**Security & Privacy**
Data security (see also Cyber Security) is an important element of CMS capability, especially in recent years as high-profile data breaches have been publicised (and related disclosure requirements have been established), and as cyber threats have escalated. Public assets, particularly critical infrastructure, are prime targets for these threats.

CMS's must employ appropriate security measures including secure user authentication and access controls to ensure only authorised staff have access to appropriate parts of the CMS. Encryption must be used to ensure data is encrypted and data transmission is secured.

Data privacy is another related element which requires CMS providers to ensure their software maintains data privacy in accordance with legislative requirements, particularly where sensors collect any personal information about staff or members of the public. In Australia, the privacy protection framework is government by the Privacy Act 1988 and laid out in the Australian Privacy Principles. In New Zealand, the Privacy Act 2020 establishes a similar set of Privacy Principles.

**Data Accessibility & Management**

One of the critical issues that has emerged after decades of deploying software is that the data created by and contained within that software has enormous value beyond the utility it provides within each system. As organisations look for greater efficiencies and society looks for more socio-economic growth, more and more complex issues need to be addressed, and all this data needs to be easily available to do that. However, software deployments almost never considered how to easily make the data available to the organisation to be used outside of the system. This has resulted in a paralysis of sorts where organisations do not have easy access to the data that their systems create to be used for other purposes including in higher order analytical work (predictive and prescriptive analytics).

Increasingly, CMS systems will need to be designed to allow the user organisation to easily access the raw data without needing to contact the provider and manually request it, so that they can use it in other systems and for other purposes.

# 3 | Case Studies

The following summaries of case studies focus on different aspects of asset tracking and monitoring in the public sector or related sectors where close parallels have relevance to those managing public sector assets and infrastructure. Hyperlinks to public source documents are included.

## Ipswich City Council

A growing council with a large footprint, a dozen depots and more than 425 vehicles successfully implemented fleet telematics across its entire fleet.

### Key Insights

- Quickly locate vehicles
- Insights into vehicle utilisation
- Timely servicing
- Tool to investigate complaints about driver behaviour

## Stows Waste Management


A 120-year-old Melbourne waste management firm successfully implemented fleet telematics across a fleet of 14 vehicles including several specialist vehicles.

### Key Insights

- Real-time visibility of fleet
- Improved route planning
- Dispensed with an array of paper-based processes
- Maximised fuel tax credits including retrospective claims

## City of Burnside

This council in one of the oldest areas of Adelaide successfully implemented fleet telematics across its entire fleet.

### Key Insights

- Better understanding of driver behaviour and where to target retraining
- Quick resolution of customer complaints about drivers
- Better safety and welfare oversight of drivers working alone

## Hiway Group

Hiway Group is a large civil contractor operating across ANZ which successfully implemented fleet telematics across more than 200 pieces of plant.

### Key Insights

- Better understanding of equipment location and utilisation across wide area
- Optimised equipment use
- Bigger fuel tax credits
- Streamlined and documented pre-start inspections
- Export of data into analytics package expected to provide biggest long-term benefit

## Konvoy


Konvoy is managing more than 70,000 beer kegs across ANZ with asset tracking.

### Key Insights

- Excellent example of positive business case for tracking low value assets
- Delivering much better asset data for both the company and its customers

## Leeton Council

Leeton Council, located in regional NSW, manages the water supply for its residents and is monitoring key pumps with smart sensors.

### Key Insights

- Monitoring enabled move to predictive maintenance regime, saving $50,000 per year for each major pump
- Monitoring has minimised interruptions to water supply, especially on hot days

## Melbourne City Council

Melbourne City Council is controlling access to its sporting grounds with remote access control.

### Key Insights

- Remote access control built on top of existing security panels
- Offers seasonal access control by sporting code

## Gold Coast High Rise

Owners of a Gold Coast high rise wanted to monitor a building making unusual noises in high winds.

### Key Insights

- Three weeks of monitoring with wireless sensors was able to prove that there were no structural issues and help identify cause
- Excellent example of low-cost, temporary sensor deployment in response to an immediate need

## SEA Gas


SEA Gas is implementing monitoring of a 10km section of a 700km pipeline using cameras and AI linked via LoRaWAN networks and satellite.

### Key Insights

- Remote access control built on top of existing security panels
- Offers seasonal access control by sporting code

## City of Joondalup

The City of Joondalup, WA, is monitoring bins and environmental conditions in a park.

### Key Insights

- Three weeks of monitoring with wireless sensors was able to prove that there were no structural issues and help identify cause
- Excellent example of low-cost, temporary sensor deployment in response to an immediate need

# 4 | Developing a Business Case

IPWEA's Asset Tracking and Monitoring Program caters for the needs of a broad market, with many potential asset types and use cases across a range of organisations. Even though the asset tracking and monitoring market is still emerging, it has existed for a few years in some asset categories but is nonetheless characterised by fragmentation.

This context is an important nuance in the design of the Asset Tracking and Monitoring Program. Producing a single model business case template is not possible for such a wide array of possible use cases and technologies. IPWEA's focus is therefore on informing, educating, persuading and empowering organisations to help them develop their own business cases as needed.

Having assessed the asset tracking and monitoring market, IPWEA believes the application of asset tracking and monitoring technology to managing assets provides significant benefits across a growing array of use cases.

For example, as discussed in Section 2.2.1, the most common user estimate reported in a recent IPWEA member survey of the simple payback period for fleet telematics deployments was a highly attractive 1–2-years. This is not dissimilar to the claims of suppliers suggesting short simple paybacks for not just fleet telematics but also many other asset tracking and monitoring use cases.

More broadly, 2019 research published by Telsyte in relation to asset tracking and monitoring technology in Australia found that organisations across all economic sectors expect a 134% return on investment in these technologies (a $1.34 return for every $1 spent on asset tracking solutions). While this research was not focussed exclusively on the public sector, the data again strongly suggests that the benefits from these technologies for the public sector are likewise favourable.

This is not to suggest that every possible asset tracking and monitoring application will achieve a high return but many are clearly now doing so. Ultimately, each organisation will need to construct a basic business case for each asset tracking and monitoring use case to determine the benefits of it in proper context.

The purpose of developing a business case for asset tracking and monitoring solutions is to demonstrate a reasonable level of due diligence in assessing each opportunity which then allows an organisation to act with confidence in addressing the problems it has identified by implementing the recommendations contained in the business case.

A business case typically focusses on the main drivers whilst including some detail about other factors. This allows sponsors and the leadership team to effectively evaluate the business case in alignment with functional or organisational directives.

In simple terms, a business case **defines the current problem/s (or opportunity)** in relation to the relevant assets, **recommends a solution** to address the problems or opportunity, **identifies the resources** (and costs) needed to implement the solution and **quantifies the benefits** of implementing the recommended solution. These four key facets of a business case are briefly discussed below:

1. **Defining the Problem(s) or Opportunity**
   It's important in developing a business case to begin by clearly articulating the problem or problems that the organisation faces and is trying to solve or conversely, the opportunity that has been identified. This is contained within a problem or opportunity statement around a central theme that will resonate with stakeholders and leaders.

2. **Recommending the Solution**
   Based on the problem / opportunity statement, the author will then document the requirements for the asset tracking and monitoring solution ensuring that this is done in simple terms, mapping the requirements to something that stakeholders and decision makers are concerned about. The author will then identify a range of options (and associated costs, benefits and risks for each). In reality, it is rare to find a solution that will address every requirement at a commercially justifiable price, so it's important to prioritise and focus on the most important requirements. The basis of recommending a solution should be based on comparative analysis of the alternative solutions in relation to the most important requirements. It should also include consideration and discussion of the commercial delivery models available, which in many cases, may be unfamiliar to the organisation.

3. **Identifying the Resources & Costs**
   Estimating all the direct and indirect costs to implement and support the recommended solution over the required term is the next step. The costs will need to be compared with the quantified benefits to accurately assess the viability of the proposed solution. Costs to consider include those related to up-front resources, recurring resources and any other resources.

4. **Quantifying the Benefits**
   Clearly documenting the business benefits of the recommended solution is the final step in building a robust business case. Quantify the benefits in financial terms wherever possible. Focus on both hard benefits (in terms of reduced actual spend or savings) and soft benefits (benefits that are demonstrably achieved even though they are harder to quantify and which should include consideration of socio-economic benefits for almost all public sector organisations) to support your recommendation to make the investment. Focus on the main problem / opportunity statement but also include benefits from other areas. Note that the value of the underlying asset is very often the key determinant of whether a business case makes sense or not though for critical assets and assets such as access infrastructure, the secondary consequences of them not being easily located or available when needed or working properly may far outweigh their direct value.

   One of the challenges in developing a business case is establishing a baseline from which the predicted benefits can be quantified. Without existing asset tracking and monitoring technology, data is often not available to establish the baseline which makes this difficult. When a large deployment is contemplated, conducting some small-scale technology trials to assist in establishing the baselines against which the predicted improvements can be measured may have merit. These results can then be extrapolated to a full deployment.

   Analysis of the benefits will also need to clearly lay out the underlying assumptions on which they have been calculate and outline any significant risks to the benefits not being realised and proposed risk mitigation strategies.

To assist our members and stakeholders in preparing a business case for an asset tracking and monitoring use case, IPWEA has incorporated a business case outline as a key deliverable in the online training which supports its Asset Tracking & Monitoring Program. This outline is supported by extensive discussion of the possible benefits that those preparing a business case may wish to consider.