

Sensing Technology Application Guidelines

For Victorian Government Controlled
Infrastructure Assets

The Secretary
Department of Treasury and Finance
1 Treasury Place
Melbourne Victoria 3002
Australia
Telephone: +61 3 9651 5111
Facsimile: +61 3 9651 2062
dtf.vic.gov.au

Authorised by the Victorian Government
1 Treasury Place, Melbourne, 3002

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1. Introduction

Sensing technologies are increasingly being used to provide new insights into the built environment. The application of this technology is widespread and may extend end to end across a project or asset lifecycle. Sensing technologies are increasingly integrating with control and automation capabilities thus continuing to increase sensing technologies' value and utility.

There are many applications where the use of sensing technologies is leading to new insights such as data driven project delivery decisions, optimising asset utilisation operations (including automation) and performance, risk and cost optimisation, asset decommissioning and disposal, tracking sustainability targets, all driving towards a connected and smart built environment.

Victoria's social and economic wellbeing depends on its infrastructure. Each day, Victorians rely upon the continuity of important services provided by its infrastructure assets. Infrastructure assets support our most basic needs: safe drinking water, food, reliable transport, accessible public health services, energy for homes and industry, access to banking, finance and government services, and global communications networks to connect us socially and in business.

The rapid global evolution and use of the Internet of Things (IOT), Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL) and Big Data means the Victorian Government needs a policy, regulatory and legislative landscape that both guides the use of sensing technologies applied to public infrastructure and evolves as new applications emerge. This policy provides a framework for Victorian Government asset owners, managers and project teams to apply rapidly developing sensory technologies and capture opportunities to realise operational efficiencies and improve investment decision-making. Throughout development and refinement of the policy, best practice from relevant jurisdictions has been analysed and adopted to ensure the viability and practicability of the policy.

Application of sensors on physical assets has the potential to provide a step change in actionable insights through more accurate, granular, and useful data on the state of an asset and its performance. As sensing technology becomes less expensive, more accurate and validated in a variety of environments, it is expected that its application will increasingly be viewed as a key requirement.

2. Purpose

This policy is designed to guide when and how to consider the application of sensing technology on Victorian Government controlled infrastructure assets, to:

- \ assist asset owners, operators and directors to discharge their legal and ethical obligation, to;
 - execute all reasonably practicable steps to understand the state of the assets under their control or ownership and to put in place the processes and procedures required to keep their assets in safe working order as required by the:
 - (ii) Occupational Health and Safety Act 2004,
 - (iii) Emergency Management Act 2013;
 - (iv) any other asset or activity safety related legislative and regulatory instruments that may apply; and
 - (v) relevant Victorian Government ICT policies particularly cybersecurity and cyber safety requirements.
 - recognise obligations under the *Financial Management Act 1994*, to provide 'a budgeting and reporting framework that is consistent with the principles of sound financial management to inform the provision of sustainable social and economic services and infrastructure fairly to all Victorians'.
- \ provide awareness of the use of rapidly developing sensing technologies and the opportunities to realise operational efficiencies and improve investment decision-making;
- \ understand and manage risk introduced through application of these technologies;
- \ understand any potential risks or detrimental impacts of asset failure on individual life, communities and economies that may be significantly reduced through the adoption of these technologies; and
- \ ensure that the benefits of new sensing technologies can be effectively realised to the benefit of the Victorian Government and Victorians.
- \ Facilitate condition-based approaches to maintenance to improve the utilisation, sustainability, and cost-efficiency of Victoria's infrastructure assets.

3. Roles and responsibilities

The success of achieving enhanced outcomes using sensing technology depends on being able to appropriately articulate the benefits. It also requires the use of experienced resources to identify and detail opportunities, costs and potential trade-offs as early as possible in the DTF Investment Lifecycle and for use with existing assets. It also requires a culture of strong leadership, outcomes focus, value for money, cost awareness, appropriate governance and accountability.

The table below details the different responsibilities of stakeholders across all stages of the DTF Investment Lifecycle and Asset Management Accountability Framework (AMAF).

User	Responsibility	Actions
Central Agency (DPC/DTF)	Ongoing oversight and advising the Premier, Treasurer and other Ministers on budget bids or investment decisions	Understand and assess investment considerations related to the application and potential use of sensing technology and how its use may create value across other assets and portfolios
Accountable Officer, Asset Owner and Senior Responsible Officer (SRO)	Ongoing accountability for the ownership and operation of the asset Establishing the data and information which the scope is based on	Ensure that adequate budget and capability is embedded within the project to enable the development and delivery of appropriate sensing solutions Provide information to improve the quality of the scope, bases of design, estimate and schedule
Asset Management Team	Ongoing accountability for the operation and maintenance of the built asset	Ensure that adequate asset management budget and capability is established and maintained to monitor, plan and manage asset condition to satisfy intended use, standards and regulations Ensure appropriate sensing technology is considered as part of client requirements for all new projects and existing assets with appropriate hand over mechanisms for projects in place to leverage long term operational benefits
Project Team	Managing a project through its development and delivery Managing project governance activities Delivering within the approved budget, time, and scope constraints Developing and implementing processes for considering and incorporating the use of sensing technology within the project	Identify better practice through the application of sensing technology Manage stakeholder expectations regarding project delivery and options considerations Ensure asset managers are engaged appropriately in the specification and benefits realisation assessment of any new sensing technology considered

User	Responsibility	Actions
Business case writer or advisor	Developing a business case for investments	<p>Ensure that business cases are based on sound assessments of the use of sensing technology</p> <p>Ensure the benefits of sensory solutions should be clearly articulated and the costs and benefits measured where possible</p>

4. Further information

For further information on sensing technology, please contact Office of Projects Victoria (Department of Treasury and Finance) at enquiries@opv.vic.gov.au.

5. Key Concepts

(a) Sensors and measurement

Sensors are used to acquire information by detecting visual, physical, chemical or biological properties quantifying those properties and converting them into a readable signal. They may be analogue, digital or a combination of both.

Most signals occurring in the real world are analogue in nature (i.e. they provide a continuous stream of information about a physical attribute), which must be transformed into a digital form (i.e. convert temperature or position to a numerical reading of defined accuracy at set intervals) to inform decision making or provide feedback. This can be through a manual interface or an automated system.

(b) Tele-communication, data transfer

The use of sensing technology is facilitated by the ability to transfer data from the sensor to a local, central, or distributed control repository to aid data processing and control. This is particularly important for asset owners with a dispersed asset base.

Communication requirements will influence the design and implementation of sensing technologies, with key considerations including data transmission size, frequency, power, and security.

(c) Systems to support sensor data interpretation

Sensor data often requires integration into, for instance, through a local physical interface (e.g. cubicle or junction box) located in close proximity to the asset or through a Supervisory Control and Data Acquisition (SCADA) or other asset management

information system. This allows further analysis of data, remote observation or intervention or control of automation.

Systems to consider how data is utilised, interpreted and visualised is required to be considered e.g. what software is used, and what programming is required for this software

(d) Safety

Sensors have a key role in improving worker or public safety, through being able to actively protect people and the environment by monitoring-for and responding to potentially dangerous conditions.

Sensors may be used to strengthen and complement existing practices within a hierarchy of controls, with priority on elimination of hazards above the use of automated safety systems to control or reduce safety risk. Where sensors provide a safety function, the integrity and probability of failure of the system is measured using a Safety Integrity Level (SIL), which is a quantification of the risk reduction provided by a Safety Instrumented Function (SIF) for a specific hazardous event.

Where a sensor can or may be part of a system providing a safety function, the use of SIL ratings as described in standards such as AS 61508 assists asset owners in demonstrating that the hazard has been reduced So Far As is Reasonably Practicable (SFAIRP) as required under section 12 of the Occupational Health and Safety Act.


(e) Data security, governance and privacy requirements

The data from an asset will remain in the ownership of the asset owner, however data gathered should be able to be deidentified to allow its use as part of a wider data pool for asset management and performance, such as in a Digital Twin Victoria platform. Data governance should balance the policy requirement¹ for data to be made available to the public (with exclusions for critical infrastructure² where security considerations may apply) against privacy considerations. Where sensor installation is widespread, the cumulative effect of data collection creates the potential that individuals may be deidentified through patterns in the data. This risk should be considered in addition to existing established processes, legislative, and regulatory requirements around privacy.

Security of all physical devices: sensors, edge devices etc. as well as data transfer and cloud services should be considered carefully with the asset (data) owner to ensure the appropriate security requirements are set for the solution considered. Consideration is to be given to the risk and nature of the data that is generated as a guiding principle to the determination of security requirements.

(f) Condition-based maintenance

Condition-based maintenance is a data-driven preventative maintenance approach that includes assessment of the actual physical condition of the asset. This can utilise



sensing technologies to provide real time monitoring of asset condition to plan replacement and repair activities.

Condition-based maintenance regimes utilise asset maintenance, operational, and inspection data to monitor the condition of the asset, leveraging statistical methods to understand how performance is degrading and forecast when failure may occur. Better monitoring through sensors allows organisations to maximise asset utilisation between maintenance, replacement or remediation activities to reach the desired balance between predictive and corrective maintenance. This optimises lifecycle costs of infrastructure systems and reduces downtime.

6. Implementation

The application of sensing technology should be considered as early as possible in the DTF Investment Lifecycle to inform the development of the project solution.

Using sensing technologies for new investments and existing assets may:

- (a) Obtain more granular and timely information on infrastructure assets where the consequences of catastrophic failure are extreme. This should reduce the insurance cost to the state and provide greater assurance of citizen and worker safety.
- (b) Inform whole of life asset management strategies, thereby potentially shifting asset management practices from reactive to those that are scheduled or periodic based on need (e.g. condition-based maintenance). This may also improve the ability, and hence reporting burden, to complete risk surveys to understand asset condition. This will result in reducing the whole of life cost of the asset as well as other benefits such as increased sustainability and/or performance.
- (c) Provide more accurate data to inform the design of assets. This includes providing more accurate information regarding appropriate safety factors and design parameters based on actual utilisation, which can be incorporated into improved standards to support leaner, more accurate designs and lower build and replacement costs. All of these will contribute to improving sustainability and reducing the environmental impact of our built assets.
- (d) For the purposes of asset usage monitoring to inform a more accurate view of the condition and performance of an asset, focusing on the potential to extend the life or increase the capacity of the asset and inform its useful life or residual value.
- (e) Inform potential future levels or enhance capabilities of existing systems for automation or remote operations.
- (f) Inform strategies to reduce the carbon footprint of physical infrastructure throughout its life.
- (g) Allow individuals to make better decisions by providing real time asset data around public services (e.g. wait times at a hospital). This may assist in maximising asset utility by shifting patronage to periods of low utilisation.

Careful consideration of the type and use of sensors should be made to better understand what information is required to improve decision making throughout a project and into asset management. Importantly, the output of any sensing solution and resulting benefits realised by project deliverers, asset owners and/or operators, should be a primary factor in ensuring the most appropriate solutions are considered. Selection of solutions should consider the potential to utilise data gathered by private sector sensors (e.g. mobile phone tower data) where this may realise more cost-efficient outcomes.

Sensor technology should be strongly considered for significant, priority or infrastructure assets to provide a greater level of protection to the value of that asset and drive reduced costs, better utilisation and overall improved asset management. The hardware may be incorporated into the asset itself, or within users of the asset (e.g. installing sensors within rolling stock to monitor the condition of rail track, or conversely installing sensors on rail track to monitor rolling stock condition).

For large scale applications, consideration should be given to proof of concept or trial implementations to optimise the ultimate solution.

Sensing technology can be used to assist with the following applications:

\ Asset and network planning:

- Site selection e.g., power sub-station, power lines, pipeline infrastructure

Geotechnical and geophysical site investigation

\ Asset Management:

- Monitoring the structural integrity of assets such as bridges, towers, poles, etc.
- Monitoring land subsidence around infrastructure
- Assessment of vegetation encroachments
- Asset condition management: damages, degradation, corrosion, etc. For example, there is a distinct shift away from reliance on periodic based maintenance programs to condition-based maintenance regimes brought about by the availability of sensing technologies.

\ Operational risk management

- Asset monitoring and event detection for natural hazards, such as floods, fires, earthquakes and land subsidence. Geospatial analytics based on satellite-based remote sensing data has been used to detect risks of natural hazards such as fire, flooding and land subsidence to assets such as roads, energy distribution grids and pipelines, powerplants, substations and dams.
- Inform emergency management decisions based on real time data from active disaster zones.
- Risk management dashboards providing insights and decision support based on geospatial analytics.

\ Regulation or law enforcement:

- For example, on the road network, sensors could be used to measure vehicle weight, which when combined with speed cameras, could result in the application of fines or could be used to support enforcement activities for road management (requiring the data to be available in close to real-time as possible to be effective).

Case study 1 - Tram patronage estimation

The Department of Transport is trialling a sensor technology solution on tram platforms to detect the number of passengers entering and exiting platforms. The intention is this will improve tram patronage estimation, which is currently limited by gaps in Myki data arising from passengers not always touching on and off. The patronage data is used to:

- monitor network operation and performance, aiding efficient network operation and identification of problem areas
- calibrate demand forecasting models, enabling data-driven network planning, project development and evaluation
- in future, with the right data transfer and management processes in place, enable real-time tram crowding information to be communicated to passengers to enable informed travel choices

Case study 2 - Port supply chain monitoring

As part of the Victorian Government's initial response to the 2020 Victorian Ports Review, the Department of Transport (DoT) implemented a Voluntary Port Performance Model to enable a comprehensive understanding of the Victorian supply chain and bring transparency to costs and performance across the supply chain. This includes monitoring of performance indicators at the stevedore landside interface with road transport operators. The indicators requiring measurement include truck queue times and near-port arterial road transit times.

DoT is currently developing a proof of concept to determine the feasibility of sensory technology and Machine Learning Processes to collect data to measure the indicators. The data would be transferred to a cloud-based environment from which the data can be cleaned to develop dashboards to report the performance indicators. The data would also be made accessible for broader use in DoT functions, maximising the value of the sensory technology solution.

Case study 3 – Real time sewer network intelligence

Intelligent Water Networks (IWN), Barwon Water and Deakin University are conducting a smart sewer network initiative in the township of Lorne. Lorne was selected due to its fluctuating population, resulting in variable demand on the sewer network and the risk of the environmental impact of a sewer spill. This intelligence will provide information for informed decision making rather than reactive events.

7. Requirements

When preparing an assessment of the potential use of sensing technology, it is a requirement that the costs and benefits be assessed on a whole of life cost basis.

It is also a requirement that a plan for ongoing management be proposed that considers:

- \ Which agency owns and is responsible for maintenance of sensors and physical communications infrastructure
- \ Which agency owns and is responsible for the data
- \ Nomination of a senior data owner in the responsible agency
- \ Agencies directly utilising or deriving benefits from the data collected
- \ Data security, assurance, and quality control mechanisms
- \ Privacy requirements and risks inherent to the collected data
- \ Extent to which data sets are available to other parties and made publicly available, including consideration of how data could be combined with data sets owned by others to deidentify individuals
- \ Outline of the way the data will be obtained, extracted, or transmitted and used (use cases), the value of the uses, and the processes, people, systems, and tools that will support these uses
- \ The structure and method in which data is stored and shared, and how interoperability can be ensured with other data sources, solutions (including sensors), and the existing asset information model
- \ Consideration of the broader applications of the data generated, ensuring it is accessible for future use cases through a defined interface where possible to maximise its value
- \ Where sensors form part of a safety function:
 - Level of risk reduction required
 - Testing and maintenance requirements to ensure the functions continue to achieve their required reliability

8. Government policy and industry standards

The application of sensing technologies requires active whole of government participation and integration with relevant government policies. In particular:

- \\ Victorian government data sharing and open data policies³, including under the *Victorian Data Sharing Act 2017*, and open data under DataVic access policies.⁴
- \\ Strategies for maintenance of digital assets such as the *Victorian Digital Asset Strategy*, *DEWLP's Core Spatial Data Services Strategy*.⁵
- \\ Privacy considerations⁶ under the *Privacy and Data Protection Act 2014* and *Health Records Act 2001*.
- \\ Data protection⁷, security and recordkeeping considerations under the *Privacy and Data Protection Act 2014*, and the *Victorian Protective Data Security Standards and Public Records Act 1973*.
- \\ Human rights considerations under *Victoria's Charter of Human Rights and Responsibilities*, including the right to privacy and reputation.
- \\ Data management and data governance, based on Data Management Body of Knowledge (DAMA DMBOK).
- \\ Data ethics and social licence considerations. There is currently no Victorian Government wide framework for data ethics but see for example the Commonwealth Government's AI Ethics Principles⁸.
- \\ ISO 9001 quality management
- \\ ISO 27001 Information Security Management Systems
- \\ AS/NZS ISO/IEC 27002 Information technology - Security techniques - Code of practice for information security management
- \\ ISO/IEC 27017 information technology equipment compliance testing
- \\ AS/NZS 60950 cloud computing
- \\ IEC 61508 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems
- \\ ISO/IEC 30128:2014: generic sensor network application interface.

Asset owners are subject to a range of statutory and policy obligations and constraints that defines the ability of third parties to access their infrastructure. For example, VicTrack is subject to the *Transport Integration Act*, *Telecommunications Act*, *Radio Communications Act*, and rail safety requirements

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10. Glossary

This glossary contains only terms that are not widely used and have a meaning specific to this document. Accordingly, terms such as 'artificial intelligence (AI)', 'infrastructure', 'asset' and 'structure' have not been included in this glossary.

Term	Description
Asset Management Accountability Framework (AMAF)	The Asset Management Accountability Framework assists Victorian Public Sector agencies to manage their asset portfolios and provide better services for Victorians.
Investment Lifecycle and High Value High Risk Guidelines (Investment Lifecycle Guidelines)	The Investment Lifecycle and High Value/High Risk Guidelines (Investment Lifecycle Guidelines) provide practical assistance to those proposing investment projects in Victoria. Investment Lifecycle and High Value and High Risk Guidelines / Department of Treasury and Finance Victoria (dtf.vic.gov.au)
Investment Management Standard (IMS)	The Investment Management Standard is a process for applying simple, common-sense ideas and practices that help organisations to direct their resources and achieve the best outcomes from their investments.
Remote sensing	Remote sensing involves collecting and interpreting information about an asset without being in physical contact, or proximity of that object.
Sensing technology	Sensing technology is a technology that uses sensors to acquire information by detecting the physical, chemical, or biological property quantities and convert them into readable signal.
Victorian Digital Asset Strategy	The VDAS sets out the vital process for safeguarding the digital systems that will allow us to monitor and improve the creation and management of infrastructure assets in Victoria.