Infrastructure Common Data Model for the Australian Infrastructure Sector Literature Review

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Research Project: SBEnrc 2.11.2

Date: October 2026

Acknowledgements:

This research has been developed by Australia's Sustainable Built Environment National Research Centre (SBEnrc). The SBEnrc develops projects informed by industry partner needs, secures national funding, project manages the collaborative research and oversees research into practice initiatives. Current core Members of the SBEnrc include ATLAS, Government of Western Australia, Queensland Government, Transport for NSW, Sunshine Coast Council, Curtin University, The University of Queensland, Western Sydney University and RMIT University. The industry-driven research outlined in this publication would not have been possible without the valuable support of our core industry, government and research partners.



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1. Purpose and Context

Information about infrastructure assets is produced by many actors, in many software environments, across decades of asset life. Fragmentation between these systems causes three problems: data lost at handover, the same data captured more than once, and limited capacity for digital transformation. The Infrastructure Common Data Model (ICDM) responds by defining a shared structure of entities, relationships and metadata that persists across lifecycle stages and software platforms. It is an integration layer above existing standards, not a replacement for them.

This report reviews existing standards, guidance and practice relevant to a common data model for infrastructure and draws out what the project can learn from them.

The review focuses on four essential areas in each standard, guideline or program:

1. **Purpose and layer:** what problem it solves, and at which layer (information process, data content, exchange format, reference data, or geospatial).
2. **Governance:** who owns it, and how it is maintained and changed.
3. **Adoption:** how widely it has been taken up, and what drove or blocked uptake.
4. **Relevance:** what it offers for the project's priorities, which are lifecycle continuity, BIM–GIS integration, and carbon and cost info.

Three groups of sources are covered, including:

- **International standards bodies:** ISO, buildingSMART International and the Open Geospatial Consortium (OGC).
- **Australian agencies and associations:** Transport for NSW, Austroads, IPWEA, ANZLIC and the Victorian Government.
- **National programs abroad:** the United Kingdom, the Netherlands, Finland, and the European road directors' INTERLINK project.

Section 2 reviews the standards and Australian guidance. Section 3 reviews international programs that have built and run common data models. Section 4 draws together the lessons learned across all of them.

2. Standards and Common Data Model Review

2.1 Information management and exchange

The ISO 19650 series (ISO, 2018a, 2018b, 2020, 2025) governs how information is specified, exchanged and managed. It is now complete in six parts, with Part 6 on health and safety published in 2025, and revisions of the core parts are under consultation in 2026. The series deliberately does not define the entities and attributes of a road, bridge or drainage network.

The series is organised in six parts:

1. **Part 1, concepts and principles:** the vocabulary and the information management cycle.
2. **Part 2, delivery phase:** how an appointing party specifies, procures and accepts information during design and construction.
3. **Part 3, operational phase:** how information is managed while the asset is in use.
4. **Part 4, information exchange:** the criteria for exchanging and accepting information containers.
5. **Part 5, security-minded approach:** how sensitive information is identified and protected.
6. **Part 6, health and safety:** how health and safety information is captured and shared across the lifecycle.

Together, the parts cover the whole asset life, from appointment to operation.

ISO 19650 gives an asset owner a chain of requirements:

1. **Organisational information requirements (OIR):** what the organisation needs to know.
2. **Asset information requirements (AIR):** what it needs about each asset.

3. **Exchange information requirements (EIR):** what each appointed party must deliver.
4. **A common data environment:** where that information is held.

Part 5 adds a security-minded approach (ISO, 2020). The series leaves the content of each requirement to the owner. Transport for NSW cites this point directly: ISO 19650 does not mandate a single handover schema because "large owners and operators have bespoke needs" (Transport for NSW, 2022b). ISO 19650 provides the process and should be adopted as it stands. The open question for any common data model is therefore content: what the AIR actually contain, and how they are expressed consistently across owners.

IFC 4.3 brings infrastructure into the open exchange schema. Published as ISO 16739-1:2024 (ISO, 2024), IFC 4.3 extends the schema to roads, railways, bridges, ports and waterways, including alignment-based linear referencing and georeferencing. Software support lags the standard by one to three years, so the ICDM should treat schema version as first-class metadata and expect a mixed-version environment. Three companion standards provide reusable mechanisms:

- **The Information Delivery Specification (IDS):** machine-checkable requirements.
- **The buildingSMART Data Dictionary (bSDD):** governed property definitions.
- **COBie:** handover structure.

IFC 4.3 was developed through buildingSMART International's infrastructure projects for roads, rail, bridges, and ports and waterways, which were merged into a single release. It adds spatial structure elements for these facilities, such as IfcRoad, IfcRailway, IfcBridge and IfcMarineFacility. It also introduces IfcAlignment, which describes a route through its horizontal, vertical and cant layouts, and allows elements to be positioned by their distance along an alignment (ISO, 2024). For asset owners, linear assets can now be exchanged in an open, ISO-standard schema together with their position along the network. The open schema now reaches the asset types that Australian transport agencies manage. However, there will be a period in which software support is incomplete.

IDS 1.0 was approved as a final buildingSMART standard on 4 June 2024 (buildingSMART International, 2024). It lets an owner state the information it requires in a form that people can read and software can check, replacing spreadsheets and PDFs with computer-interpretable specifications. An IDS file is an XML document. Each requirement in it is built from six facets: entity, attribute, classification, property, material and part-of. Each specification states which objects it applies to and what information they must carry, so a delivered IFC model can be checked by software before it is accepted. IDS is aligned with ISO 19650. More than 200 contributors from 34 countries took part in its development, and about a dozen software implementations were available at release (buildingSMART International, 2024).

The buildingSMART Data Dictionary (bSDD) is an online service that hosts classification systems and property definitions published by many organisations. It makes them available to software through an interface. Publishing definitions there allows design and asset management tools to look up the same agreed meaning, rather than each project re-typing property lists. Requirements can now be stated once and checked automatically at delivery. Definitions can be shared through a common dictionary rather than copied into project documents.

COBie (Construction Operations Building information exchange) originated in the United States as a structured, spreadsheet-based format for handing over facility information for operations and maintenance. It forms part of the US National BIM Standard, and its structure is built around facilities, floors, spaces, systems and components. COBie shows the limits of reusing a building standard for infrastructure. Transport for NSW does not mandate COBie, because it was designed for buildings and cannot represent linear assets or fleet. TfNSW uses its own Digital Engineering Asset Register instead. That register carries data COBie omits, including asset owner, operations and maintenance contracts, condition and risk. It also supports exchanges throughout the asset life, not only at handover (Transport for NSW, 2022b). Infrastructure handover needs structures designed for networks and long operating lives, not adapted from buildings.

2.2 Geospatial and BIM–GIS integration

Geospatial and BIM traditions still meet project by project. OGC CityGML 3.0 (OGC, 2021), LandInfra/InfraGML (OGC, 2016) and the ISO 19100 series supply geodetic coordinates, city-scale

semantics and linear referencing (ISO 19148; ISO, 2021). However, no governed specification tells Australian agencies how to keep one asset representation that serves both the BIM and GIS traditions.

CityGML 3.0 (OGC, 2021) is a conceptual model for semantic 3D city and landscape models. It organises the city into thematic modules, including buildings, bridges, tunnels, transportation and construction. It also introduces a space concept that separates physical objects from the spaces they bound. Three new modules matter for asset management:

- **Versioning:** records how objects change over time.
- **Dynamizer:** links objects to time-varying data such as sensor readings.
- **PointCloud:** allows objects to be represented by point clouds.

LandInfra (OGC, 2016) covers land and civil infrastructure facilities, including alignments, roads, railways, survey observations and land division; InfraGML is its encoding in GML. **ISO 19148** (ISO, 2021) defines how to locate features by measured distance along a linear element. This is the method road agencies use when they record assets by chainage. The geospatial standards already describe infrastructure as time-varying, network-referenced objects, and can even carry point clouds. The missing piece is agreed practice for keeping a BIM object and its GIS counterpart linked as the same asset.

The Australian guidance on this point is ANZLIC's *Principles for Spatially Enabled Digital Twins of the Built and Natural Environment in Australia* (ANZLIC, 2019). It adapts the UK Gemini Principles (Centre for Digital Built Britain, 2018) to Australia. Nine principles say that a digital twin should:

1. deliver public good;
2. provide ongoing value;
3. provide enough information to assess quality;
4. adapt as technology and society change;
5. be as open as possible;
6. be secure and privacy-preserving;
7. have clear curation responsibilities;
8. use consistent agreed standards;
9. be based on a federated model connecting data custodians.

Custodians keep their own data and connect it through agreed standards, rather than moving it into one central store. A common data model in Australia therefore works best as a shared meaning across custodians, not as a single database.

2.3 Australian standards and guidance

Australian instruments overlap without alignment. Each of the instruments below embodies an implicit common data model. None is national, and together they define the fragmentation the ICDM addresses. The model's value to agencies is mapping and convergence, not replacement.

Transport for NSW Digital Engineering Framework. Version 4.0 (DMS-ST-208, December 2022) is the most complete agency framework in Australia (Transport for NSW, 2022a). It is built from several parts:

- **Standards:** concepts and principles (DMS-ST-202) and requirements (DMS-ST-207).
- **Project data schemas:** separate schemas for BIM, CAD, GIS and scheduling deliverables.
- **A Master Classification Library,** with guidance on applying Uniclass.
- **An asset register template** for operations and maintenance data.

The framework is organised around four aims:

- creating a digital twin of the TfNSW network;
- standardising digital engineering requirements in procurement;
- providing enabling technology, such as common data environments and enterprise content management;

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- building capability through a Digital Engineering Panel.

Project teams work from standard templates, including the digital engineering execution plan and the asset register. Delivery follows a seven-step process: TfNSW preparation, procurement, contractor establishment, design and delivery, TfNSW review, contractor resubmission, and approval (Transport for NSW, 2022a).

The framework is tied into TfNSW's investment assurance gates and configuration change board. A working data model in Australia already exists inside one agency. It is enforced through procurement and assurance, and it uses an international classification (Uniclass) rather than a home-grown one.

ADAC (Asset Design and As Constructed). ADAC is a standard specification for describing asset design and as-constructed data, maintained through IPWEA Queensland (Moreton Bay Regional Council, n.d.). Developers and contractors convert survey data into XML following the ADAC schema, and councils load it into their systems for validation and acceptance. It captures eight asset classes: cadastre, open space, water supply, sewerage, stormwater, supplementary, surface and transport (Rockhampton Regional Council, 2023).

The current version of the schema is 5.0.1. Logan City Council, for example, requires compliant ADAC XML files in this format for operational works approvals granted from 1 July 2024, except for small developments of 50 metres or less of water supply, sewerage or stormwater infrastructure, or four lots or fewer. It describes compliant files as a structured and precise digital record of the assets that transfers directly into its asset registers and GIS (Logan City Council, n.d.). Rockhampton Regional Council checks every submitted file for format and conformance and returns files with significant errors for correction. It still accepts the older versions 4.0 to 4.2 where necessary, and notes that vendors of ADAC XML generators receive schema updates free of charge (Rockhampton Regional Council, 2023). Local government has a mature, machine-validated handover schema with years of practical use. Any national effort should map to ADAC rather than ask councils to replace it.

Austroads Road Asset Data Standard (RADS). The Austroads Road Asset Data Standard: Version 4 (Austroads, 2022) specifies the data that supports the common operational activities of road agencies and their suppliers across Australia and New Zealand. It also guides funding agencies on how reports and submissions should be structured, so that investment decisions rest on evidence. Work on the standard began in 2014; version 1 was released in November 2016 and version 4 in October 2022 (Austroads, n.d.). It contains 988 data measures in 14 functional groups: network, classification, inventory, condition, demand, utilisation, criticality, risk, resilience, asset performance, financial performance, service performance, access, and works and costs. The inventory group alone covers 32 data classes, from pavements and bridges to traffic signals (Austroads, 2022, n.d.). Rather than requiring all 988 measures, the standard defines tiered Priority Data Sets:

- **Core:** 141 measures, the minimum for asset management;
- **Extension 1:** 175 measures, adding condition and service data;
- **Extension 2:** 216 measures, with a local government focus;
- **State road authority:** 227 to 239 measures for state agencies.

The standard is voluntary. Road managers do not need to change their existing systems, because it works as a reference document that different platforms can map to. It is published as a PDF and in machine-readable CSV, JSON and XML formats. It is maintained by the Austroads Assets Task Force, which includes the state and territory road agencies, the National Transport Commission, the Commonwealth infrastructure department, and local government through IPWEA (Austroads, n.d.). Harmonising definitions, not systems, is achievable nationally. A tiered set of priority data, starting from a small core, lets organisations of very different maturity adopt the same standard.

Victorian Digital Asset Strategy (VDAS). The VDAS guidance, issued by the Office of Projects Victoria, applies to all Victorian Government infrastructure asset types (Office of Projects Victoria, n.d.). It requires each agency to:

- appoint a VDAS Champion with board-level accountability;
- define its organisational, asset and exchange information requirements;

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- implement them through digital engineering execution plans.

It references ISO 19650, ISO 55000, ISO 41011, the Gemini Principles and the FAIR data principles, and it aligns with Victoria's Asset Management Accountability Framework. Implementation follows five steps:

1. Assign a VDAS Champion.
2. Develop an implementation roadmap.
3. Define organisational and asset information requirements.
4. Deliver projects in line with the roadmap.
5. Review performance and refine the approach.

Contractors respond to the agency's requirements with a Digital Engineering Execution Response. The guidance points to the Virtual Building Information System (VBIS) as a public-domain asset classification (Office of Projects Victoria, n.d.). Governance is set at the top of each organisation, through named accountability, before any data standard is chosen.

2.4 Carbon and lifecycle data

The project's focus on carbon and cost info means carbon data standards are part of the landscape. Three groups are relevant:

- **Product-level data:** EN 15804 (CEN, 2019) and ISO 21930 (ISO, 2017) define environmental product declarations (EPDs) for construction products.
- **Whole-life assessment:** EN 15978 (CEN, 2011) for buildings and EN 17472 (CEN, 2022) for civil engineering works set out how product data is assembled into lifecycle stages, from product supply (A1–A5) through use (B), end of life (C) and beyond (D).
- **Linking to BIM:** ISO 22057 (ISO, 2022b) provides data templates for using EPD data in BIM, so that carbon values can travel as properties of model objects.

EN 15804 divides a product's life into information modules:

- **A1–A3:** product stage;
- **A4–A5:** construction process;
- **B1–B7:** use stage;
- **C1–C4:** end of life;
- **D:** benefits and loads beyond the system boundary.

The 2019 amendment, EN 15804+A2, expanded the set of environmental indicators and made the end-of-life modules and module D mandatory for most products (CEN, 2019). EN 17472 applies the same modular logic to civil engineering works such as roads, bridges and tunnels (CEN, 2022). ISO 22057 uses standard data templates so that each EPD indicator becomes a defined property that software can attach to a BIM object (ISO, 2022b). With these standards, a quantity of concrete or steel in a model can carry its embodied carbon, and the totals can be reported by lifecycle stage.

The standards that carry carbon data on model objects already exist. A common data model needs to point to them, not define its own carbon structure.

2.5 Data quality, governance and security

- **Data quality:** the ISO 8000 series (ISO, 2022a) and ISO/IEC 25012 (ISO/IEC, 2008) define measurable data quality characteristics.
- **Provenance:** W3C PROV-O provides a standard way to record where data came from (Lebo et al., 2013).
- **Security:** ISO 19650-5 sets out security-minded information management (ISO, 2020). Under the *Security of Critical Infrastructure Act 2018*, owners of critical infrastructure assets carry risk management obligations. The Australian Signals Directorate's Information Security Manual and Essential Eight set the baseline controls (Australian Signals Directorate, n.d.-a, n.d.-b).

Each of these has practical detail relevant to infrastructure data:

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- **ISO 19650-5** asks the asset owner to assess the sensitivity of its information and, where needed, to prepare a security strategy and a security management plan that control who can access what (ISO, 2020).
- **PROV-O** describes provenance through three core classes: entities, activities and agents. A record can therefore state what it was derived from, by what process and by whom (Lebo et al., 2013).
- **The SOCI Act** was expanded by amendments in 2021 and 2022. These extended it to eleven sectors, including transport, energy and water, and require owners of specified critical infrastructure assets to adopt and maintain a risk management program (Security Legislation Amendment (Critical Infrastructure) Act 2021; Security Legislation Amendment (Critical Infrastructure Protection) Act 2022).

For infrastructure owners, information about asset location, condition and dependencies can itself fall within these obligations.

Quality, provenance and security already have standard vocabularies. A common data model should carry them as metadata on every record, rather than handle them separately. ANZLIC's principles add one tension to manage: digital twins should be as open as possible but secure. Where that balance sits has to be agreed with each custodian.

3. International Practice

Governance decides success, not schema sophistication. The international programs that have built and run common data models for infrastructure share this lesson. The programs that succeeded combined persistent identifiers, controlled vocabularies, disciplined change control, procurement integration and a single accountable custodian. Where ambition came before demonstration, adoption was slow. The table summarises five programs, and each is then described in turn.

Program	Country	Scope	Approach	Who governs it	What drove adoption
Information Management Framework	UK	All national infrastructure	Top-level ontology, reference data library, integration architecture	National Digital Twin programme	Government policy; still emerging
Asset Data Management Manual (ADMM)	UK (England)	Strategic road network	Data dictionary and asset reference catalogue	National Highways, with a named custodian	Contract requirement for suppliers
Object Type Library (OTL)	Netherlands	Rijkswaterstaat roads and waterways	Object types with properties and relations, published as linked data	Rijkswaterstaat (AIRBIM program)	Basis for BIM project databases
INTERLINK	Europe	National road authorities	Harmonised OTLs, with data left at source	CEDR research program	Research stage
Inframodel	Finland	Infrastructure design and construction	LandXML-based open exchange format	Industry consortium; accepted by buildingSMART (2012)	Vendor support and client procurement

UK Information Management Framework (IMF). *The Pathway towards an Information Management Framework* (Hetherington & West, 2020), published by the Centre for Digital Built Britain, sets out three components for a national system of connected digital twins:

- **A Foundation Data Model:** a top-level ontology for time, space, causality and classification.
- **A Reference Data Library:** controlled vocabularies, for example settling whether “door” includes the frame.
- **An Integration Architecture:** for discovery, authorisation and transformation of legacy data.

It follows the Gemini Principles (Centre for Digital Built Britain, 2018) and works top-down and bottom-up at once. The foundation data model draws on philosophical ontology and existing industry models, while

the reference data library grows from existing authoritative sources. The document itself warns that mapping legacy systems will be “significant”, and that backwards compatibility after release puts a “heavy cost on users” (Hetherington & West, 2020).

A public consultation on the pathway closed in August 2020.

- **Support:** sixteen of the 24 respondents welcomed the approach and agreed with its three components.
- **Technical doubts:** several questioned whether a single foundation data model is practical given the diversity of legacy data, and how non-semantic data such as point clouds and video would be handled.
- **Barriers to adoption:** respondents named resistance to change and a lack of direct, tangible benefit.
- **Wider frameworks:** they stressed that legal, commercial, regulatory and governance frameworks must be developed alongside the technology (Centre for Digital Built Britain, 2021).

The review shows that a full ontology gives rigour, but it is slow and costly to adopt, and technical design alone does not create adoption. The reference data library, the part closest to everyday practice, is the most transferable element.

National Highways Asset Data Management Manual (ADMM). The ADMM (version 13, October 2021) is the authoritative statement of National Highways' asset data requirements (National Highways, 2021). It has four parts:

1. Data principles and governance.
2. Requirements.
3. A data dictionary.
4. An asset reference catalogue.

Data is organised into nine lifecycle categories: inventory, plan and design, construct, maintenance and renewal, condition and performance, operate, retirement, system, and information. For each item of data, the manual records where it comes from, what purpose it serves, and who is responsible for populating and updating it. The scope covers pavements, structures, drainage, geotechnical assets and operational technology, together with carriageway inventory.

Governance is explicit:

- **Roles:** a named ADMM custodian maintains the document, the Asset Management Development Group owns formal changes, and a review panel of stakeholders is consulted on significant change.
- **Change control:** changes are classed by impact as minimum clarification, business as usual, or step change. Each is submitted through a standard change request form, assessed for impact, and recorded in a revision log.

The ADMM is the authoritative source of National Highways' asset data requirements for contract management, legislative compliance and decision-making (National Highways, 2021). The review shows that this is the clearest working example of custodianship and change control, and of lifecycle coverage that runs through to retirement. Its authority comes from being tied to contracts.

Rijkswaterstaat Object Type Library (OTL). Rijkswaterstaat's OTL holds the definitions, properties and relationships of the object types the agency manages (Rijkswaterstaat, 2019). It is maintained by the AIRBIM program and published openly in numbered versions, and a modelling instruction explains how to build BIM project databases on it. Because the library is versioned and public, contractors and software vendors work from the same definitions as the owner. The review shows that an owner-specific object library, openly published and versioned, gives every project a single reference point without waiting for a national standard.

CEDR INTERLINK. The INTERLINK project ran from September 2016 to August 2018. It was funded through the CEDR Transnational Research Programme and delivered by TNO, Royal HaskoningDHV, and Roughan & O'Donovan. It developed a framework for a European Road OTL (Luiten et al., 2018).

The framework uses W3C linked data standards:

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- RDF as the data model;
- RDFS, OWL and SHACL to define object type libraries;
- SPARQL for queries.

It links to existing BIM and GIS standards, such as IFC and InfraGML, rather than replacing them. National libraries develop independently, among them CB-NL in the Netherlands, BSAB in Sweden and OKSTRA in Germany. Concepts they share are promoted to the European level. Road asset data "remain at their source" and are shared over the web.

Three test cases were run:

1. **Germany:** bridge handover in Hamburg, linking IFC and OKSTRA data.
2. **Nordic countries:** linking pavement condition data with road network data.
3. **Netherlands:** sharing pavement inspection data from mobile applications with agency databases.

The proposed roadmap moved in three stages: a basic framework for CEDR, then national adoption, then a long-term maintenance organisation formed with buildingSMART, ISO and W3C (Luiten et al., 2018). This development is a bottom-up, federated approach that lets each authority keep its own library while agreed concepts are shared. This matches the federated direction of the ANZLIC principles.

Finland's Inframodel. Inframodel is an open, LandXML-based format for passing infrastructure data between design, construction and maintenance, so that information is not lost between project stages. Its third version, Inframodel3, was developed by the Infra FINBIM program (2010–2013) with 15 companies and three research organisations, and was accepted by buildingSMART in 2012. Major civil design packages, including Tekla Civil, Novapoint and InRoads, added import and export. The format was published openly to encourage wider use. Public clients such as the City of Espoo began requiring 3D models and 3D machine guidance in contracts (Heikkilä & Laatunen, 2013). The review shows that adoption needed three things at once: a national specification, software vendor commitment, and client procurement that rewards its use. A specification on its own was not enough.

4. Lessons Learned

Eight lessons recur across the standards, guidance and programs reviewed. None depends on a single source. Each is described below with the evidence behind it and what it means for infrastructure owners in Australia.

4.1 The process is solved; the gap is content

ISO 19650 already defines how information is required, exchanged, secured and accepted across the asset life (ISO, 2018a, 2018b, 2020, 2025). Australian guidance builds on it rather than replacing it. The Victorian Digital Asset Strategy requires organisational, asset and exchange information requirements in ISO 19650 terms (Office of Projects Victoria, n.d.). The TfNSW framework sets out a seven-step delivery process with templates for execution plans and asset registers (Transport for NSW, 2022a).

What ISO 19650 leaves open is the content of those requirements: which objects an owner manages, and which attributes each must carry. TfNSW notes that the standard leaves this to owners because they have bespoke needs (Transport for NSW, 2022b). Every program in section 3 is, at heart, an effort to fill that content gap: the ADMM data dictionary, the Rijkswaterstaat OTL, the IMF reference data library and the INTERLINK framework. The lesson is to adopt the process standards as they stand, and to focus effort where practice still differs, in the content of asset information requirements.

4.2 Harmonise meaning, not systems

The most successful national effort reviewed did not require anyone to change systems. The Austroads Road Asset Data Standard gives road managers across Australia and New Zealand a common meaning for road asset data. It is voluntary, works as a reference that existing systems can map to, and offers tiered priority data sets for organisations at different levels of maturity (Austroads, 2022, n.d.). ANZLIC's principles call for a federated model in which custodians keep their own data and connect through agreed standards

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(ANZLIC, 2019). The INTERLINK framework goes furthest: road asset data remain at their source, and national object libraries are linked rather than merged (Luiten et al., 2018).

The alternative, a single central model, is the one the UK consultation questioned. Respondents doubted whether a single foundation data model is practical given the diversity of legacy data (Centre for Digital Built Britain, 2021). For a country with several state agencies, many councils and established instruments such as ADAC and the TfNSW framework, agreement on meaning, together with maintained mappings between instruments, is more achievable than agreement on one system.

4.3 Reuse international building blocks before writing new definitions

The international building blocks are now mature enough to reuse:

- **IFC 4.3** covers roads, railways, bridges and marine facilities, including alignments and linear placement (ISO, 2024).
- **IDS** makes information requirements machine-checkable, with software support from release (buildingSMART International, 2024).
- **bSDD** hosts governed definitions that software can look up.
- **CityGML 3.0** adds versioning, time-varying data and point clouds to city models (OGC, 2021).
- **ISO 22057** carries carbon data on BIM objects (ISO, 2022b).

Australian practice already reflects this: TfNSW applies Uniclass rather than a home-grown classification (Transport for NSW, 2022a).

Reuse brings compatibility with commercial software and with other owners at no extra cost. Bespoke definitions bring the opposite. The IMF authors warn that once a framework is released, maintaining backwards compatibility puts a heavy cost on its users (Hetherington & West, 2020). The lesson is to create new definitions only where the international building blocks demonstrably fall short.

4.4 Building-centric standards do not transfer to networks

Reuse must be selective. COBie was built around facilities, floors, spaces and components, which suits buildings but not transport networks. TfNSW does not mandate it, because it cannot represent linear assets or fleet. Its replacement, the Digital Engineering Asset Register, carries what COBie omits: asset owner, operations and maintenance contracts, condition and risk (Transport for NSW, 2022b).

The same caution applies elsewhere. Infrastructure assets are located by distance along a route (ISO, 2021), connected as networks, and operated for many decades. IFC 4.3 and LandInfra were developed specifically to describe alignments and linear facilities (ISO, 2024; OGC, 2016). Any template inherited from buildings should be tested against linear and networked assets before it is relied upon.

4.5 Governance and custodianship decide success

In every program that has lasted, a named body is accountable for the data standard:

- **ADMM:** a named custodian, an owning group, a review panel and a graded change process, with every change logged (National Highways, 2021).
- **Rijkswaterstaat OTL:** maintained by a dedicated program and published in numbered versions (Rijkswaterstaat, 2019).
- **Austroads Road Asset Data Standard:** maintained by the Austroads Assets Task Force, which brings together state and territory road agencies, the National Transport Commission, the Commonwealth infrastructure department and local government (Austroads, n.d.).
- **VDAS:** begins by appointing an executive champion with board-level accountability (Office of Projects Victoria, n.d.).
- **ANZLIC principles:** list curation, meaning clear responsibilities, ownership and regulation, as a principle in its own right (ANZLIC, 2019).

The UK consultation reached the same conclusion from the other side. Respondents stressed that legal, commercial, regulatory and governance frameworks must be developed alongside the technology, not

after it (Centre for Digital Built Britain, 2021). INTERLINK's roadmap ended with a formal maintenance organisation, because without one an object library becomes obsolete (Luiten et al., 2018). Technical quality matters less than having someone responsible for keeping the standard current.

4.6 Start small and extend on evidence

The Austroads standard has grown from version 1 in 2016 to version 4 in 2022. Rather than requiring all 988 of its data measures, it defines a Core Priority Data Set of 141 measures, with extension sets for richer condition and service data, local government and state road authorities (Austroads, 2022, n.d.). INTERLINK proposed an evolutionary path: national libraries develop step by step, and only shared concepts are promoted to the European level (Luiten et al., 2018). By contrast, the UK IMF began with a complete foundation ontology. Its consultation found that respondents saw a lack of direct, tangible benefit as a barrier (Centre for Digital Built Britain, 2021).

A narrow scope tied to real use cases produces evidence of value early. That evidence is what persuades organisations to invest further. A complete model that has not yet been demonstrated asks them to invest first and see benefits later.

4.7 Adoption follows procurement and software support

Every instrument that is widely used is required by someone:

- **Inframodel** spread when design software vendors supported it and public clients such as Espoo required 3D models in contracts (Heikkilä & Laatunen, 2013).
- **ADAC** is used because councils require ADAC files for asset acceptance (Logan City Council, n.d.; Rockhampton Regional Council, 2023).
- **ADMM** is the reference for National Highways' contracts (National Highways, 2021).
- **TfNSW framework** is enforced through procurement and investment assurance (Transport for NSW, 2022a).

Software support matters just as much. ADAC is produced by third-party ADAC XML generators, whose vendors receive schema updates free of charge (Rockhampton Regional Council, 2023). IDS was released with about a dozen implementations already available (buildingSMART International, 2024). IFC 4.3, by contrast, is limited in practice by software support that lags the standard. A specification no one is required to use, or cannot easily produce, is rarely used.

4.8 Cover the whole lifecycle, including condition, end of life and carbon

Most handover instruments stop at construction, which is where information loss begins. The ADMM organises data into nine categories running from inventory to retirement (National Highways, 2021). The Austroads standard includes functional groups for condition, risk, resilience, financial performance, and works and costs (Austroads, n.d.). ISO 19650 has a part for the operational phase and, since 2025, a part for health and safety information across the lifecycle (ISO, 2025). The CityGML 3.0 Versioning and Dynamizer modules allow models to record change over time and link to live data (OGC, 2021).

Carbon and cost info follow the same pattern. EN 15804 and EN 17472 define lifecycle modules from product supply to end of life and beyond (CEN, 2019, 2022), and ISO 22057 lets those values travel with model objects (ISO, 2022b). Whole-life information is much easier to retain when it is captured at design and construction than to reconstruct decades later.

Summary

Taken together, the review shows a consistent pattern:

- **What works:** adopting international process and exchange standards, agreeing meaning across organisations while leaving systems in place, and assigning clear custodianship.
- **How adoption is earned:** starting with a narrow scope, proving value, and securing adoption through procurement and software support.

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- **Where programs struggle:** where they started from a complete model, adapted building-centric structures to networks, or left governance until later.

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