TRANSPORT

Digital Engineering Standard Part 1: Concepts and Principles

IP Integrated Management System

Document number:	**DMS-ST-202**
Version:	**4.1**
Document owner:	**Director Digital Twin Integration**
Published date:	**December 2022**
Next review date:	**December 2024**

NSW GOVERNMENT

Preface

Transport for New South Wales (TfNSW) is implementing the Digital Engineering (DE) Framework (see DMS-ST-208 – *Digital Engineering Framework*) to support projects as they adopt new digital ways of working. The way assets are planned, designed, constructed, operated and maintained is becoming faster and more accurate as a result of emerging technologies. The DE Framework connects these technologies across various project disciplines together with reliable, structured data.

Consistent DE processes provide TfNSW with an approach that enables digital information to become a key enabler of better project outcomes. This includes, but is not limited to, stakeholder engagement, informed decision making, improved asset knowledge, and capability and capacity planning.

Applying this unified vision will accelerate the value of DE and simplify these new ways of working for both our project teams and industry, providing valuable insights, creating efficiencies and delivering cost savings throughout the project life cycle.

This document should be read in conjunction with all related DE Framework documentation. Any application of the DE Framework or any of its parts must be considered in a project-specific context. Adoption of the DE Framework should be undertaken in consultation with the DE team to ensure adoption of best practice.

Engagement with the Digital Engineering team

The first point of contact for the project team, implementing this DE Standard (DMS-ST-202 – *DE Standard, Part 1: Concepts and Principles* and DMS-ST-207 – *DE Standard, Part 2: Requirements*) for a TfNSW project, is your project TfNSW DE Manager.

For general enquiries and assistance with the application of this Standard and associated guidelines, education, and training, or planning and commencing a digital engineering project, please contact the Digital Engineering team at **Digital.Engineering@transport.nsw.gov.au**.

The DE Framework embraces a culture of continuous improvement. Suggestions, comments and feedback are welcomed and encouraged.

Table of contents

Table of figures

Table of tables

1 Introduction

1.1 The Digital Engineering Framework

This Digital Engineering Standard and supplementary templates, guidelines, training and resources form the Digital Engineering (DE) Framework (see DMS-ST-208 – *Digital Engineering Framework*). The DE Framework provides the tools and requirements to assist TfNSW projects seeking to implement DE. These tools will continue to be developed over time, with incremental updates and new releases of the DE Framework documents provided.

The documents available as part of the DE Framework are illustrated in Figure 1. The DE Framework documents include:

1. The **TfNSW Digital Engineering Standard** and supporting guides:
    a. The TfNSW DE project set-up, commercial and procurement guidelines and project management tools are for use by TfNSW staff implementing DE on a project, and provide guidance, contract templates, and DE tools and templates.
    b. The supporting technical guides provide practitioner-level guidance for the implementation of the specific requirements of the DE Standard, based on specific DE disciplines, and provide worked examples.
2. **Tender documents** provide guidance on the adaptation of standard TfNSW contract templates for use on DE-enabled projects. These templates reference the DE Standard, with project-specific DE requirements included in the Project Contract and/or the Project DE Execution Plan (DEXP) template. The completed DE contract documentation, project DEXP template and DE Standard are then provided to the contractor.
3. The **contractor documents**, specific to DE. This includes the project specific DEXP (Project DEXP), completed and approved for implementation by TfNSW.

Note: For complex projects where the work is to be completed as separate stages or by various subcontractors, multiple project DEXPs may be required. Where multiple plans are required, these must be aligned with a lead DEXP.

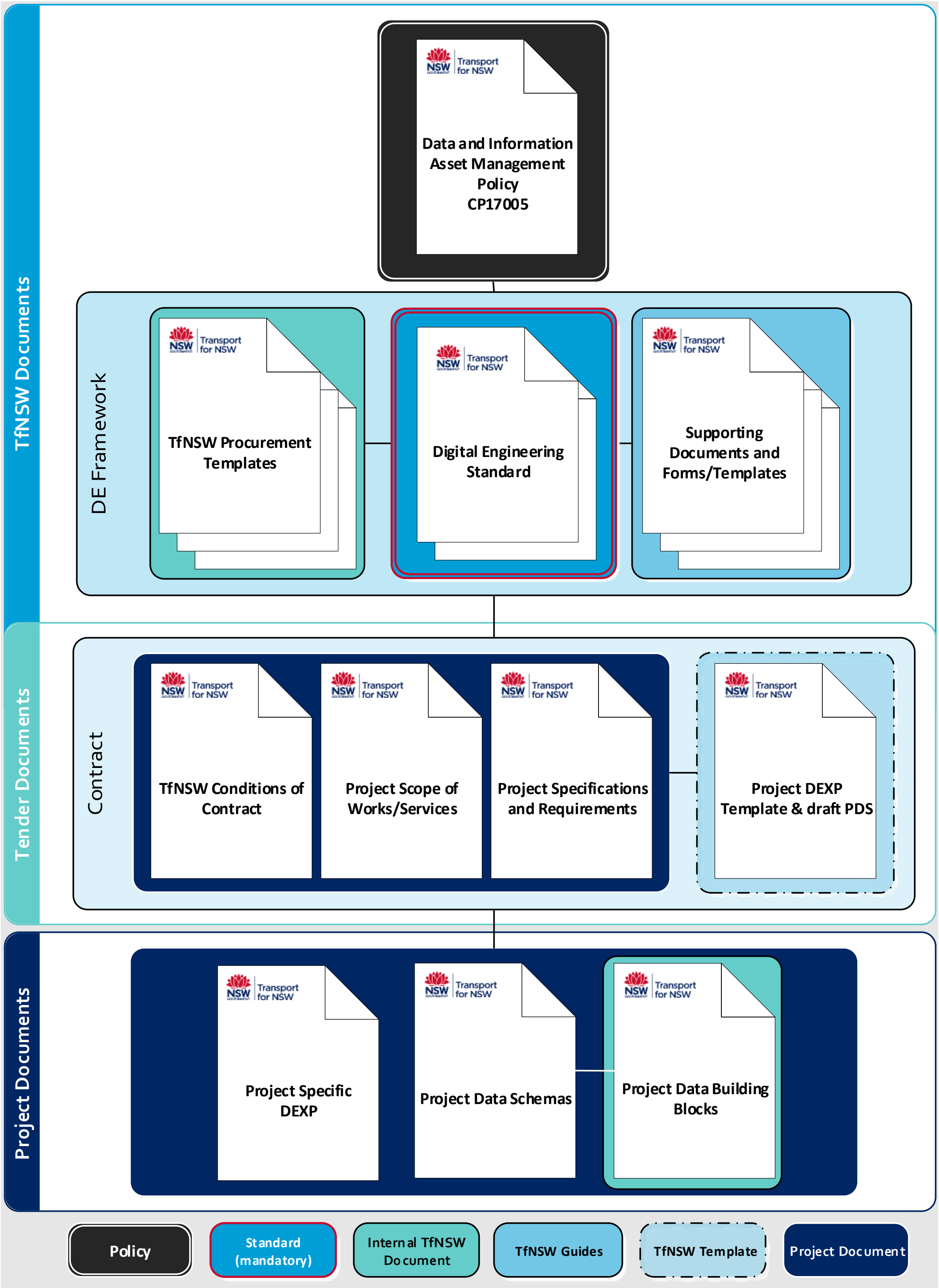


Figure 1 – Digital Engineering Framework document hierarchy for example

1.2 Purpose of this document

The DE Standard is the lead document in the DE Framework for the contractor, providing minimum requirements for the implementation of DE. It details how the *Data and Information Asset Management Policy* (CP17005.1) is to be implemented through the application of the DE Framework.

The DE Standard describes the language and approach to be adopted when implementing DE for TfNSW projects.

Specifically, this DE Standard provides requirements and guidance on:

- the structure of the DE framework, including DE's influence on the achievement of organisational and asset management objectives
- the structure and information workflow within a project team's Common Data Environment (CDE)
- the requirements for Project Data Building Blocks (PDBB) and Project Data Schemas (PDS), which is a common language and structure for all project information and data
- the implementation of 3D modelling and the expectations of how project teams should integrate BIM models into project delivery.

1.3 Structure of this document

The DE Standard is provided in two parts:

1. Part 1 (this document) – DMS-ST-202 – *TfNSW Digital Engineering Standard, Part 1: Concepts and Principles*. Providing an overview of the TfNSW operating environment and DE concepts.
4. Part 2 – DMS-ST-207 – *TfNSW Digital Engineering Standard, Part 2: Requirements*. Providing the management requirements and technical outputs (deliverables/submissions) that are required during the delivery of a TfNSW DE-enabled project.

This document is to be read in conjunction with the *TfNSW Asset Management Framework* and the *TfNSW Configuration Management Framework* and relevant agency configuration and design management plans. (see Appendix A).

1.4 Scope of the DE Standard

The DE Standard is applicable for TfNSW staff and contractors delivering physical transport assets for TfNSW during the Plan and Acquire stages (that is, during planning, design and construction), where DE methodologies are specified for project delivery. The Demand/Need, Operate/Maintain and Dispose/Renew stages of the asset life cycle are not currently within the scope of the DE Framework (see Figure 2).

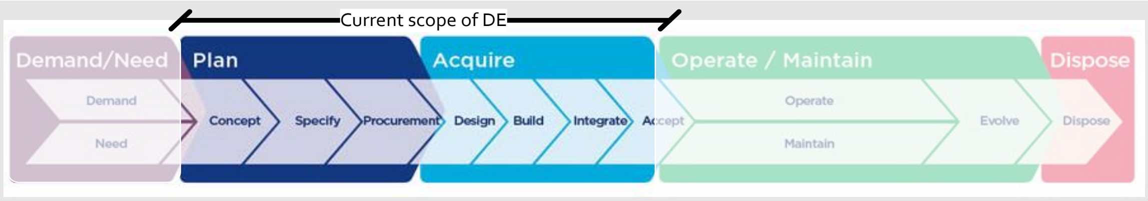


Figure 2 – Current application of Digital Engineering within the asset life cycle

When implementing DE for TfNSW projects, the DE Standard should be read in conjunction with all related requirements set out in the contract documents.

DE activities currently excluded from the scope of the DE Framework are:

- BIM for operation and maintenance
- advanced building materials
- pre-fabrication and modular construction
- 3D printing and additive manufacturing
- autonomous construction
- augmented reality
- big data and predictive analysis
- wireless monitoring and connected equipment
- cloud and real time collaboration.

It is expected these items will be covered in later releases of the DE Framework.

1.5 Terms and definitions

The terms and abbreviations used in this document have the meaning/definitions provided in DMS-SD-123 – *DE Terms and Definitions*.

1.6 References

The DE Standard refers to various TfNSW and industry standards, guidelines and specifications. Sources include:

- TfNSW Asset Management Branch (AMB) within Safety, Environment and Regulation (SER) (previously Asset Standards Authority (ASA)) and TfNSW (previously Roads and Maritime Services (RMS)) standards and procedures
- Infrastructure and Place (IP) standards and procedures

- ISO, Publicly Available Specifications (PAS) and industry standards and guidelines.

A list of references and relevant standards and guidelines is provided in DMS-ST-207 – *Digital Engineering Standard, Part 2: Requirements*.

2 TfNSW context

2.1 Overview

TfNSW manages a complex multimodal portfolio of assets, including:

- mobile assets in the form of fleet (buses, ferries and trains)
- point assets or non-linear infrastructure (interchanges, stations, stops, buildings, stabling yards, substations, wharves)
- linear infrastructure (roads, railways, utilities and services).

Each division within the Transport cluster (see Figure 3) has specific responsibilities under the TfNSW Asset Management Framework, to assist in the delivery of the Asset and Services Plans. During the Acquire stage, IP is the Asset Steward acting on behalf of TfNSW as a trusted partner, developing and delivering smart, integrated and sustainable infrastructure and places that are valued by our customers and communities.

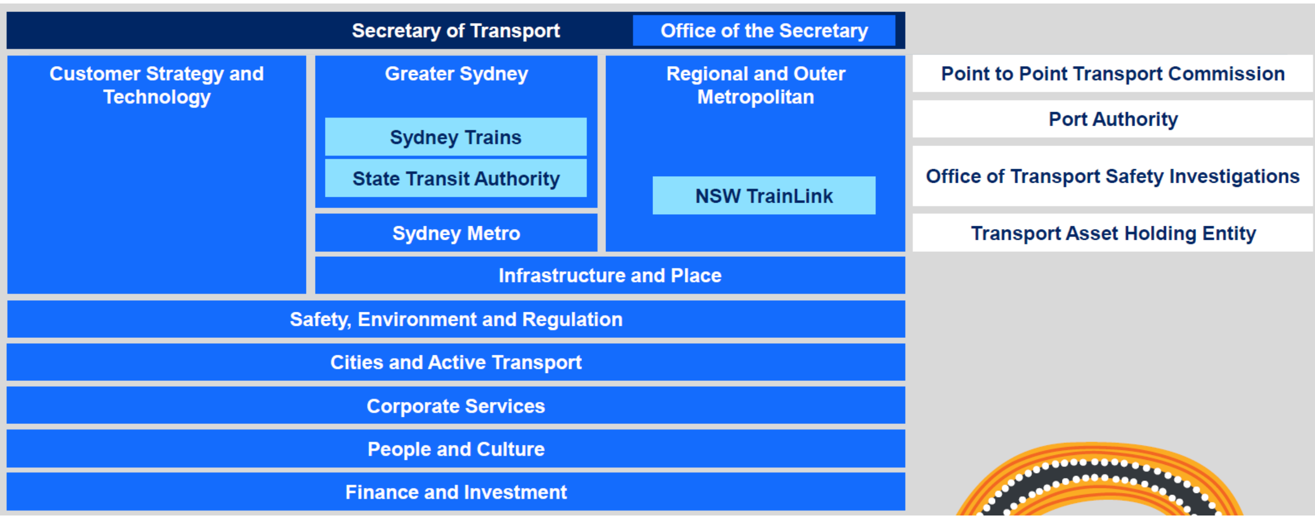


Figure 3 – Transport cluster

TfNSW was established in 2011 by bringing together a number of government departments and agencies to form the Transport cluster. In 2019, RMS and TfNSW were joined together to make one integrated TfNSW. Through this evolution, IP and each of the divisions have historically customised local asset standards, with varying data structures and information exchange requirements. This creates significant complexity in project management, design and asset management, particularly for multimodal projects with multiple asset stewards.

In addition to the interfaces created by the duplication and variety of standards, there is a broad range of commercial delivery strategies employed to design and build infrastructure projects such as internal and outsourced delivery, Public Private Partnerships (PPP), Alliances, Managing Contractors, Design Only, Design and Construct (D&C), and Construct only. These various commercial delivery strategies often create the need to exchange information between multiple interfacing contractors, creating further complexity for information management and collaboration.

The vision of the TfNSW DE Framework is to minimise this complexity, by introducing consistent data structures and open data exchange protocols, while remaining software and technology agnostic. Using consistent methods enables information to be easily exchanged between TfNSW and contractors while allowing contractors to continue using their own CDE.

The implementation of DE ensures data is structured so that it can be easily developed, shared and maintained throughout the asset life cycle.

The DE Standard has been written to support the IP division, however, the principles of the DE Framework and the DE Standard are designed to be practical and scalable for all TfNSW divisions and operating agencies, with the intent for the DE Framework to be integrated across the Transport cluster in the coming years.

2.2 TfNSW governance and control

TfNSW provides two project assurance frameworks that must be complied with by all projects delivered for TfNSW:

- Infrastructure Investor Assurance Framework (IIAF) – ensuring value for money
- Configuration Management Framework (CMF) – assuring the physical and digital (intangible information) asset.

The DE Framework has been developed to integrate with both the IIAF and CMF.

The TfNSW CMF was updated in 2022 to provide a consistent approach to configuration management and configuration change authority arrangements across the portfolio (that is, all Transport modes and assets). The CMF (2022) introduces the concept of configuration management review gates, which are aligned with the TfNSW Asset Lifecycle. The alignment of the CMF Baseline and Review Gates with the asset life cycle stages is displayed in Figure 4.

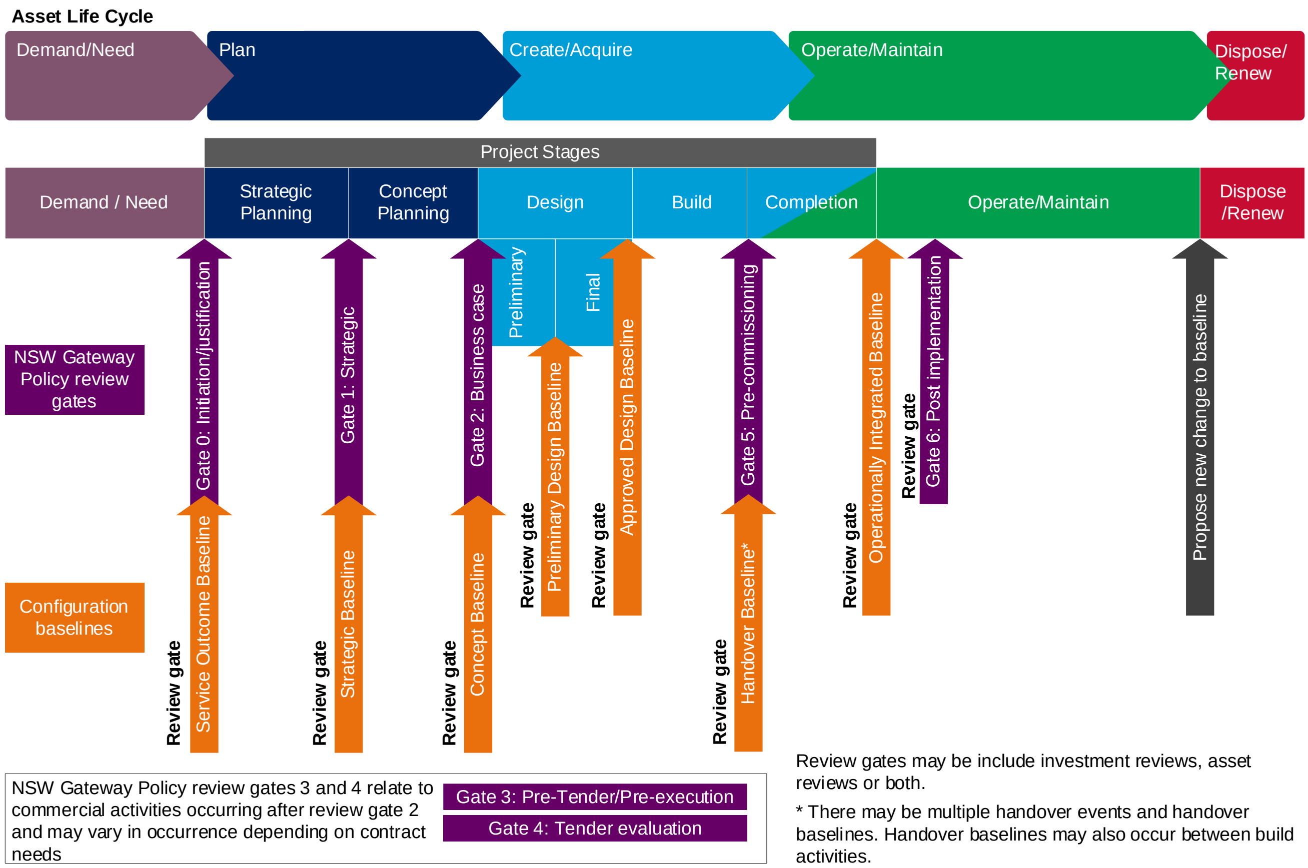


Figure 4 – TfNSW configuration management phases (*TfNSW Configuration Management Framework, 2022*)

The TfNSW Asset Management Framework (AMF) and TfNSW Configuration Management Framework (CMF) specify the requirements that apply, when planning or undertaking a configuration change at any stage of the asset life cycle. For assurance of TfNSW projects, the CMF specifies the use of:

- asset life cycle phases
- CMF submission baselines
- CMF Design Review Gates.

The requirements for the digital asset assurance are aligned with the physical asset assurance, namely the CMF Baselines and Review Gates. A summary of the intent of each Design Review Gate is provided in Table 1.

Table 1 – Asset life cycle stage and configuration management baseline design review activities

Asset life cycle stage	CMF Baseline and Review Gate	Requirements/activity summary
Plan Strategic Planning	Strategic Baseline	The Strategic Design must have a clear set of program/project outcomes that are measurable. The Strategic Design must have shortlisted options with evidence the options are viable and have been evaluated against identified TfNSW outcomes. The Strategic Design must have evidence that the implications on the sustainable operations and maintenance of the TfNSW network are broadly known for each option. The Strategic Design must have assured that the risks and impacts of the options are broadly known.
Plan Concept Planning	Concept Baseline	The Concept Design must have a clear set of business requirements that define quantitative and measurable outcomes. The Concept Design must have documented and agreed expectation of how the proposed solution will operate and be maintained as an integrated part of TfNSW's network in a way that is sustainable and supports TfNSW's outcomes. The Concept Design must have evidence that the proposed solution meets all relevant requirements. The Concept Design must have evidence that risks and impacts of the proposal are appropriately well understood, defined and manageable.
Create/ Acquire Design	Preliminary Design Baseline	The Preliminary Design must have a clear set of system requirements or equivalent detailed requirements that are quantitative and measurable and traceable to business requirements. The Preliminary Design must be progressively assured. The Preliminary Design must have evidence that the preliminary design supports relevant requirements. The Preliminary Design must have evidence that arrangements to address safety have been appropriately applied.
Create/ Acquire Design	Approved Design Baseline	The Approved Design must have a clear set of system requirements or equivalent detailed requirements that are quantitative and measurable and traceable to business requirements. The Approved Design must have a completed, appropriately assured and technically approved detailed design ready for implementation. The Approved Design must have evidence that all relevant requirements have been met.

Asset life cycle stage	CMF Baseline and Review Gate	Requirements/activity summary
		The Approved Design must have produced asset information that appropriately describes the assets and how they will be operated and maintained. The Approved Design must have assured that the solution is safe so far as is reasonably practicable (SFAIRP).
Create/ Acquire Build	Handover Baseline	The Handover Design must have evidence that an appropriately assured asset has been acquired. The Handover Design must have appropriately tested and verified the asset. The Handover Design must have evidence that the acquired asset meets the approved requirements and approved design. The Handover Design must demonstrate that the delivered solution is appropriately ready to be operated and maintained; this includes matters such as asset information, training, spares and interfaces. The Handover Design must have assured that the delivered outcome in the context of its use environment is safe SFAIRP. The Handover Design must have agreement for any risks and risk management activities that are to be transferred.
Operate/ Maintain Completion	Operationally Integrated Baseline	The Operationally Integrated Design must have evidence that all defects, outstanding deliverables and outstanding matters have been appropriately resolved.
Renew/ Dispose	Proposed new change to Baseline	Any asset that is determined for change or renew must be assessed for the Demand or Need stage and must have a defined, documented and agreed set of outcomes that TfNSW seeks to achieve.

(Source: The information in Table 1 is based on TS 01455 – *Configuration Management*.)

To accommodate the legacy ASA and RMS design assurance gates, the equivalent Configuration Management Baseline and Review Gates (CMF) and Investment Assurance Gates (IAG) are aligned as shown in Table 2.

Note: The IAG are still applicable to projects in relation to financial assurance.

For further information regarding the governance and control gates, refer to:

- *TfNSW Configuration Management Framework*
- *TfNSW Configuration Management*
- IP-294-PR – *IP Configuration Management Procedure*
- **Infrastructure NSW (INSW) Project Assurance**

- IP Divisional Management System (DMS) now replaced by IP Information Management System (IMS).

Table 2 – Multimodal review stages

Asset life cycle stages	Asset life cycle sub-stages	CMF baseline and review gates	Legacy ASA rail design stages	Legacy RMS road design stages D&C	Legacy RMS road design stages construction only	INSW gates
Demand/ Need	Demand	Service Outcome Baseline				Gate 0 Go/No Go
Plan	Strategic Planning	Strategic Baseline	SCR System Concept Review	Strategic Design	Strategic Design	Gate 1 Strategic Options
Plan	Concept Planning	Concept Baseline	SDR System Definition Review	20% Concept Design	20% Concept Design	
Plan	Concept Planning	Concept Baseline		80% Concept Design	80% Concept Design	
Plan	Concept Planning	Concept Baseline		100% Concept Design	100% Concept Design	Gate 2 Business Case
Create/ Acquire	Preliminary Design	Preliminary Design Baseline	Tendering	Reference Design	20% Detailed Design	
Create/ Acquire	Preliminary Design	Preliminary Design Baseline	PDR Preliminary Design Review	Tendering	80% Detailed Design	
Create/ Acquire	Preliminary Design	Preliminary Design Baseline		Interim Design Submission		
Create/ Acquire	Final Design	Preliminary Design Baseline	CDR Critical Design Review	Final Design	100% Detailed Design	Gate 3 Readiness for Market
Create/ Acquire	Final Design	Approved Design Baseline			Tendering	Gate 4 Tender Evaluation
Create/ Acquire	Final Design	Approved Design Baseline	AFC Approved for Construction	IFC Issued for Construction	IFC Issued for Construction	
Create/ Acquire	Build	Handover baseline	TRR Test Readiness Review	Construction	Construction	Gate 5 Readiness for Service

Asset life cycle stages	Asset life cycle sub-stages	CMF baseline and review gates	Legacy ASA rail design stages	Legacy RMS road design stages D&C	Legacy RMS road design stages construction only	INSW gates
Operate/ Maintain	Completion	Operationally Integrated Baseline	TRR Test Readiness Review	Construction	Construction	Gate 5 Readiness for Service
Operate/ Maintain	Operate/ Maintain	Operationally Integrated Baseline				
Renew/ Dispose	Renew/ Dispose					

3 Digital Engineering

3.1 Transport data and information asset management policy

TfNSW is committed to implementing best practice data and information management within a digital environment, in accordance with the *Transport Data and Information Asset Management Policy* (CP17005). As stated in this policy, Transport supports the adoption of the following principles:

- Single Source – Ensuring service and asset data is accurate, current, reliable and not duplicated
- Collaboration – Increasing access and sharing, reducing latency for improved decision making
- Automation – Reducing or eliminating manual work associated with creating or sharing data
- Interoperability – Reducing or eliminating double handling of data between systems
- Mobility – Enabling access to and input of data from multiple locations including from the filed
- Visualisation – Incorporating methods to develop, coordinate and check service and asset data spatially
- Data Governance – Comply with information management policies, including open data, data information custodianship and information security.

The application of these principles in a project context (as depicted in Figure 5) has led to TfNSW defining a common language and approach for contractors to use when developing and managing digital information, which TfNSW refers to as DE.

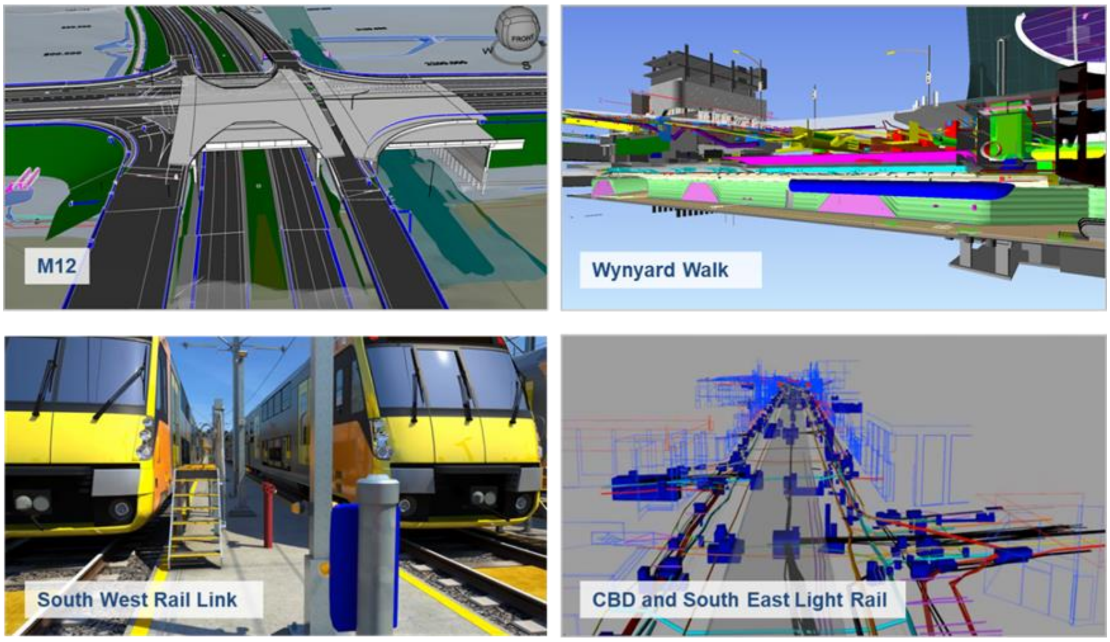


Figure 5 – Examples of Digital Engineering in use in TfNSW projects

3.2 Digital engineering at TfNSW

DE is a collaborative way of working, using digital processes that enable more productive methods of planning, constructing, operating and maintaining TfNSW's assets.

Together, these standardised ways of working collaboratively utilising digital enablers, comprise the TfNSW DE Framework (see Figure 6). The DE Framework links to or is integrated with many of TfNSW's existing management frameworks, providing a cluster-wide approach to DE.

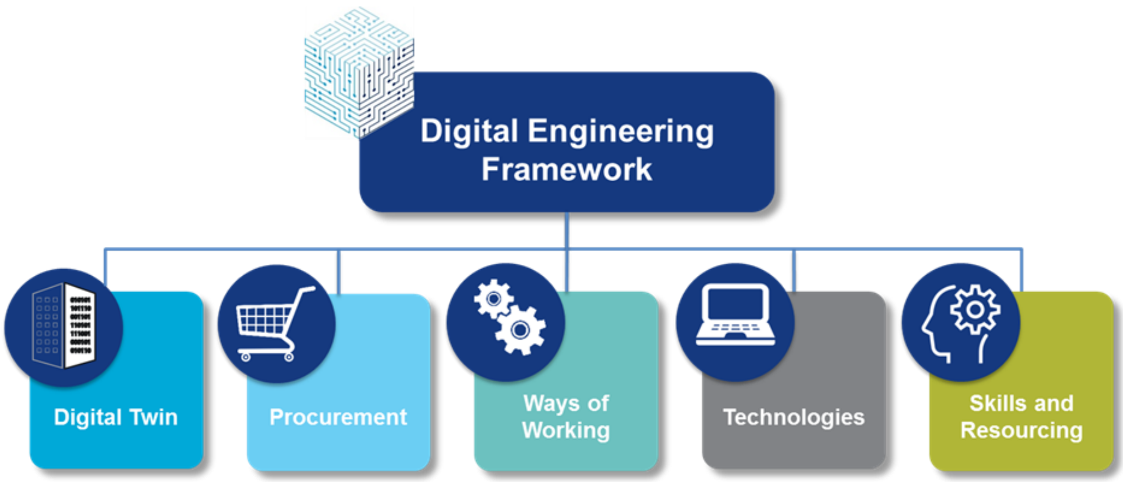


Figure 6 – Digital Engineering Framework

Implementation of a fully integrated DE Framework will lead to time, cost and quality efficiencies for TfNSW and its contractors throughout the project life cycle. See Table 3 for information on uses and benefits of DE.

Table 3 – Digital Engineering uses and benefits

DE use	Description and benefit
Systems Engineering	Alignment with model-based systems engineering and traceability from concepts, business and system requirements through to the commissioned product. Visibility and ease of sourcing validation and verification artefacts and alignment of these with requirements.
Survey	Integration and inclusion of existing conditions in design. Tracking of construction, including comparison with AFC BIM model, over the build.
Design	Integrate the design of project disciplines, including architectural, civil, structural, technology, signalling and control, and mechanical, electrical and plumbing elements of the infrastructure/asset, including the surrounding areas, assisting with systems engineering.
Coordination	The federation of the different design BIM models at key project milestones (for example, prior to a design submission) allows project teams to discover conflicts or inconsistencies before construction starts.
2D drawings	2D drawings can be extracted from the model and the drawings will be up to date, coherent and clash detected.
Visualisation and communication	BIM models (3D) can be used to communicate design solutions to designers and other stakeholders. For example, it is possible to walk through the model, create animations, and see 3D images or visualisations.

DE use	Description and benefit
Decision support	DE provides a platform to investigate different alternatives by comparing various properties such as functionality, scenarios and costs. This can assist with, for example, options analysis and can support investment decision making.
Quality assurance	DE-enabled design reviews enable discovery and problem-solving in the design phase instead of during construction. In future, TfNSW will be able to validate the design with a rule-based validation program to determine whether the requirements have been met. Models can be used for fire safety reviews, Building Code of Australia reviews and/or to check accessibility for maintenance crews.
Quantity take-off	Quantities can be extracted from BIM models for tendering, as well as for purchases during the construction phase.
Time simulation	The BIM model can be linked to a schedule and generate time simulations to assist with optimising construction sequencing.
Cost estimating	The BIM model can be linked to provide the evolution of costs during the project delivery process for automated forecasting and earned value calculation.
Analysis	DE can help stakeholders to simulate the life cycle performance of the asset, including structural, MEP, energy, acoustical and lighting analysis.
Constructability	BIM models can be used for safety planning, for example, to analyse construction site layout, including understanding the impacts and interactions with the surrounding areas.
Asset data	Use of the BIM model to create and populate key attributes of the DE Asset Register. Structured data and metadata facilitating handover of the Asset Information Model (AIM) from the project to the O&M parties.

3.3 Digital twin and Smart Places

A digital twin is a digital model of a real-life object, process or system. The digital model can be informed by historical data and fed with live sensor data to make the digital model a 'twin' of the real-life, real-time subject (Figure 7). Digital twins of discrete systems can be linked to create twins of larger, more complex systems such as a factory or a city.

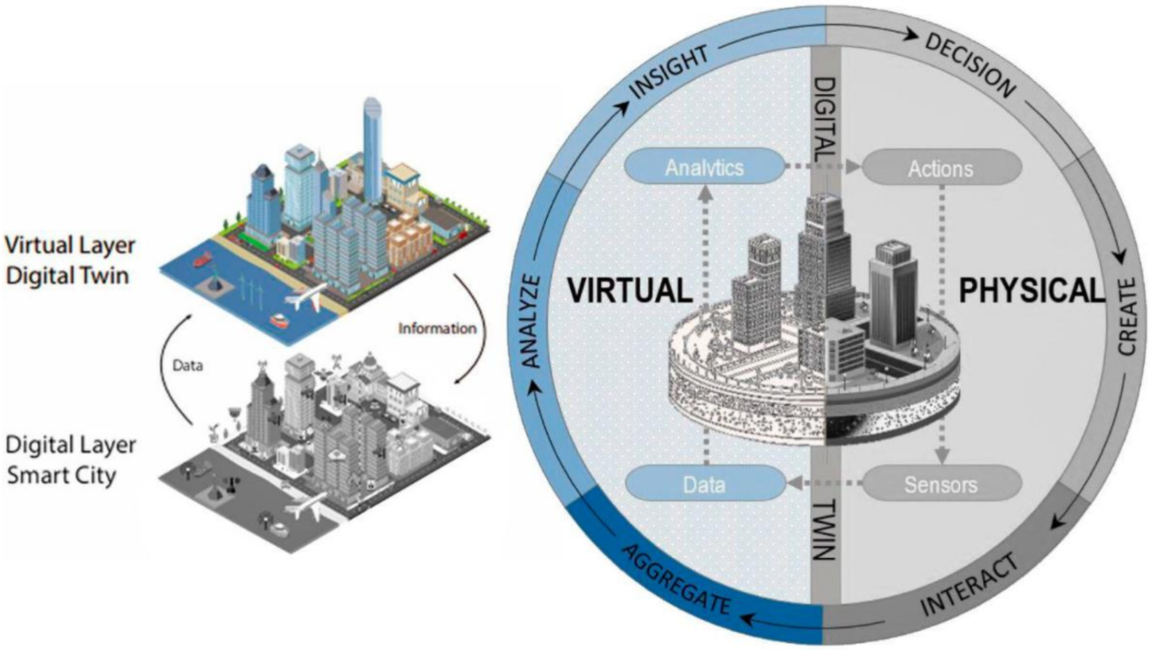


Figure 7 – Digital twin, a model of a real-life object, process or system informed by historical and live data

(Source: Caprari G. Digital Twin for Urban Planning in the Green Deal Era: A State of the Art and Future Perspectives. *Sustainability*. 2022; 14(10):6263. https://doi.org/10.3390/su14106263. Reproduced under the Creative Commons Attribution License.)

Smart Places support the quality of life in NSW, by using technology and information to solve problems and open up economic, social and cultural opportunities for people in communities, towns and cities. The NSW Government developed the Smart Places Strategy to support the development of Smart Places, and the Smart Infrastructure Policy is seen as a foundational element of the Smart Places Strategy.

The NSW Smart Infrastructure Policy sets the minimum requirements for smart technology to be embedded in all new and upgraded infrastructure from 2020 onwards (recommendation 32 in the State Infrastructure Strategy). This is a mandated policy that applies to infrastructure projects subject to the Infrastructure Investor Assurance Framework (IIAF) from late 2020.

Future Transport 2056 and the Future Transport Technology Roadmap 2021-2024, and Tourism and Transport each refer to the Smart Infrastructure Policy with regard to place making and supporting future transport options such as Mobility as a Service (MaaS), digital wayfinding, and future 'Smart Cities'.

The DE Framework supports TfNSW in delivering on the Smart Places Strategy through the provision of high-quality structured data in the project information and asset information models. This structured data supports digital twin initiatives across TfNSW, which in turn help TfNSW and the community to realise the benefits of Smart Infrastructure and Smart Places (Figure 8).

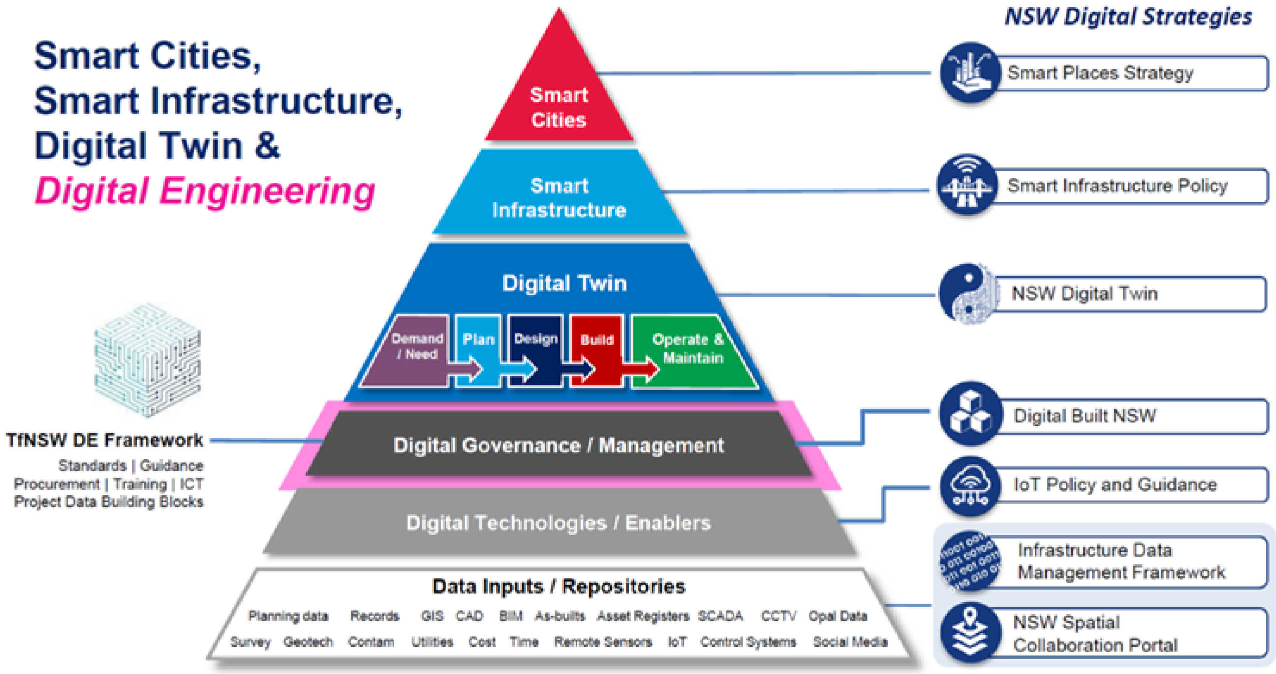


Figure 8 – Structured data supports digital twin

Digital twins are supported by the structured data aligned to the DE Framework. Digital twin supports Smart Infrastructure and Smart Places.

4 Information model concepts

4.1 Overview

The structure of the DE Framework is based on the information principles of ISO 19650 *Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling*.

An information model, as defined by ISO 19650, is a set of structured or unstructured information. This includes geometric data (including 2D drawings and BIM models), non-geometric data (including spreadsheets and databases) and any other information (for example, email correspondence and documents) required to deliver and manage an asset throughout its life cycle.

In general, information requirements structure and standardise all data that comprises the information model. The data and information that is to be provided throughout the asset life cycle (information requirements), are determined by TfNSW's objectives at each stage. The data and information are used to assess performance against the TfNSW objectives, facilitate verification of requirements and to assist in life cycle decision-making.

Figure 9 illustrates TfNSW's conceptual information model. It introduces the concept of an Organisational Information Model (OIM), for Transport portfolio-level information.

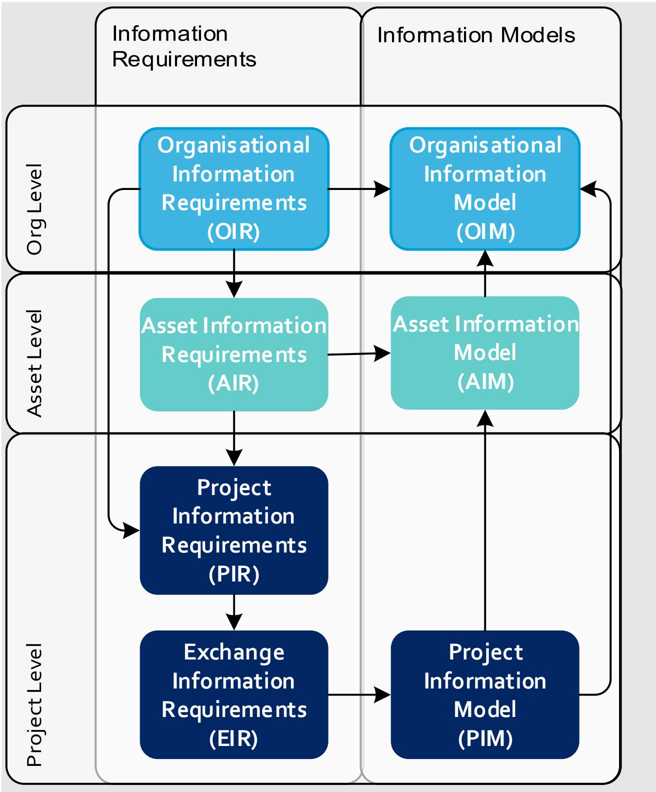


Figure 9 – Relationships between information requirements and information model

(Source: Figure 9 is adapted from ISO 19650.)

The Project Information Requirements (PIR) to be generated by a specific Contractor for contribution to a Project Information Model (PIM) is defined in the Exchange Information Requirements (EIR), which are collectively specified in the DE Standard, the contract, DEXP template and PDS (see Section 5).

The project information created during project planning and delivery (the Demand/Need, Plan and Acquire stages) by TfNSW and all contractors form the PIM.

The information handed over to the Operator and Maintainer from the PIM, and the additional information generated during the operations and maintenance phase forms the Asset Information Model (AIM).

The project AIMs contribute to the overall Organisational Information Model (OIM). The OIM enables assessment of performance against the Organisational Information Requirements (OIR).

These components are detailed further in the below sections.

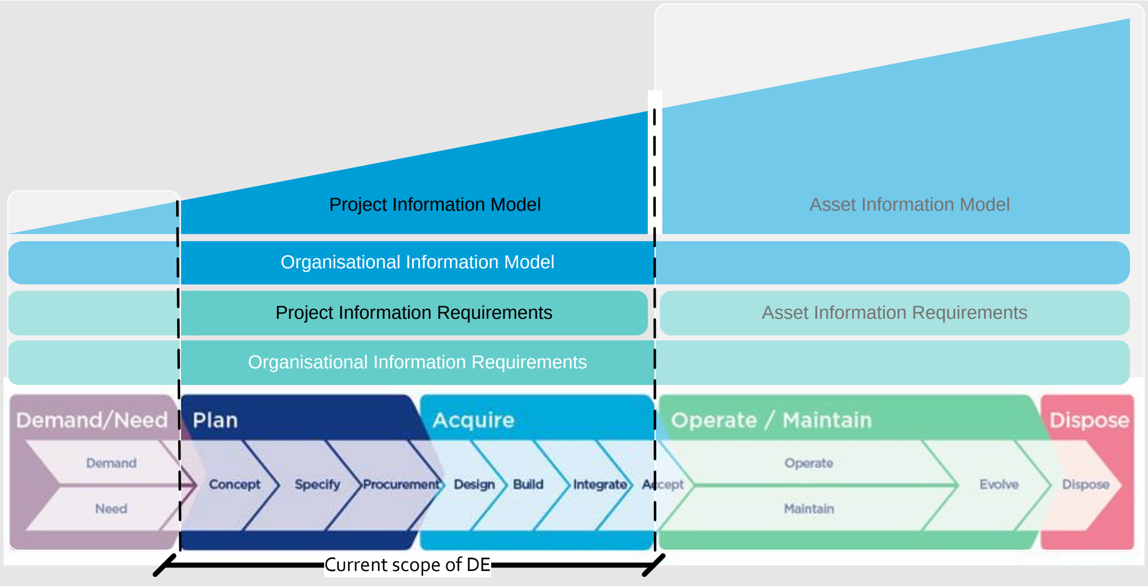


Figure 10 – Information requirements and information model integration

4.2 Organisational information

4.2.1 Organisational Information Requirements (OIR)

TfNSW's information requirements are specified in the strategy documents and frameworks developed and documented to guide business objectives and outcomes. Overarching OIR are defined in TfNSW's Future Transport Outcomes (**Future Transport Strategy 2056**). These outcomes drive key information requirements throughout the life cycle and determine the resulting information models. The integration of information requirements and information models across the asset life cycle is provided in Figure 10.

The TfNSW Future Transport Strategy is focused on six key outcomes for the future of mobility in the state, which together aim to positively impact the economy, communities and environment of NSW. Achieving these outcomes has underpinned every planning decision in the development of the Transport Strategy and drives TfNSW's asset management planning.

To achieve and measure the success of the six strategic outcomes (see Figure 11), specific information is required from the business. It is this required information that, primarily, forms TfNSW's OIR. OIR are also dictated by wider NSW Government policies and frameworks, industry compliance requirements and TfNSW group policies.

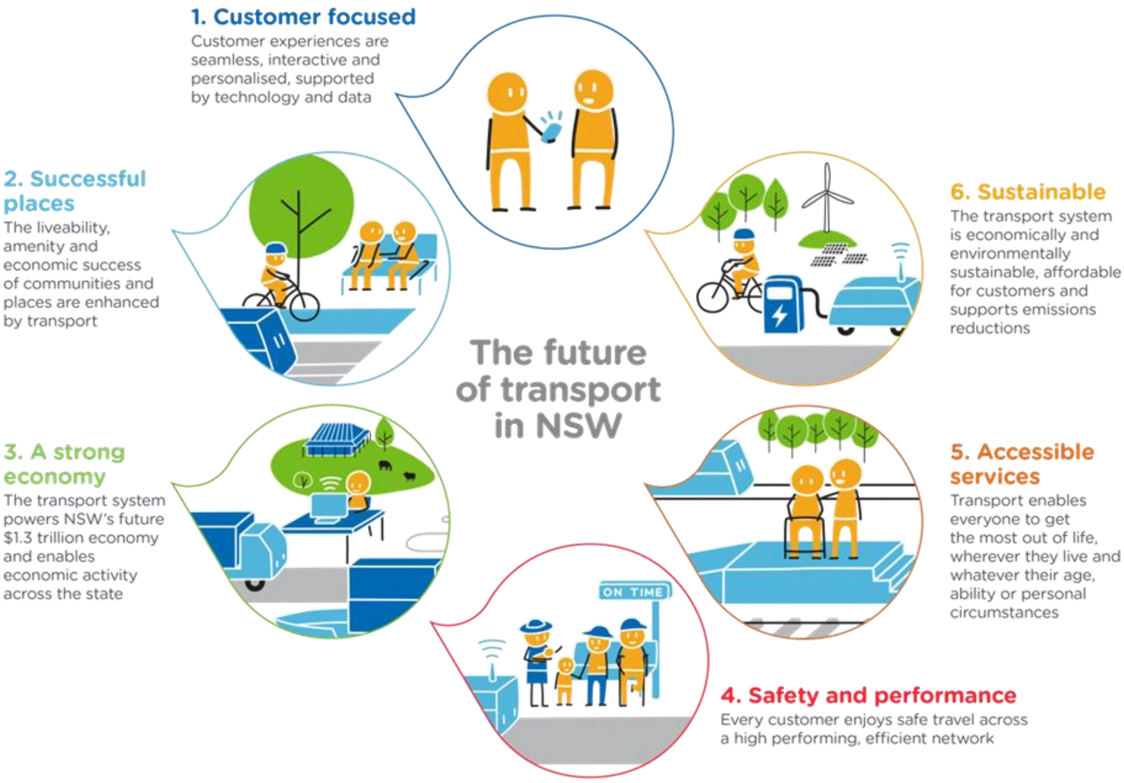


Figure 11 – TfNSW's six key outcomes (*TfNSW Future Transport Strategy*)

4.2.2 Organisational Information Model (OIM)

The OIM includes information from all project and asset information models (inter-agency and inter-modal), as well as the wider business, to provide an integrated organisation-wide information data model. Example information outputs generated from the OIM as a result of the OIR include:

- monthly and annual reporting
- business and strategic plans
- health checks
- forecasts and projections
- network and project performance
- passenger travel and satisfaction reports.

4.3 Asset information

4.3.1 Asset Information Requirements (AIR)

The AIR are generally specified by the owner's and/or custodian's asset management objectives, which in turn are derived from the OIR, and detail all information and data that is needed to manage the asset effectively.

AIR specific to the Operations and Maintenance (O&M) of the asset and generated as a result of O&M activities are defined in the O&M contract. The contract specifies the mechanism, format and frequency that the O&M information needs to be provided to support business functions during service and to aid in effective asset management.

A subset of the information required by the AIR is generated during the delivery of a project. Where this is required, these AIR are specified as part of the project PIR, to ensure that the asset data and information required is captured during project delivery.

The DE Standard incorporates AIR that are to be generated during project delivery (the plan and acquire phases) and explains the requirements for the asset information to be produced up until asset handover, referring to other TfNSW standards where applicable.

4.3.2 Asset Information Model (AIM)

The AIM is the name given to all asset information deliverables produced in response to the AIR. The AIM is generated for use in the O&M phase. Information contributing to the AIM may initially be generated during the project delivery phases and handed over from the project team to the O&M parties as part of a formal acceptance procedure. This information is then built upon by the O&M team as a result of evidence generated during operation and maintenance activities (see Figure 12).

Asset information generated by the O&M as a result of post-asset handover activities, including asset performance and condition data, is outside of scope for the DE Standard at this time.

This revision of the DE Standard specifically addresses the minimum requirements for asset information that must be generated as part of the DE process during delivery for asset handover, including:

- handover DE Asset Register
- Requirements Traceability Verification Matrix (RTVM)
- capital expenditure for capitalisation
- completed Inspection and Test Plan (ITP)
- O&M manuals
- As-Built drawings and 3D models.

It is critical to the success of DE that the AIM information is managed as a 'digital asset' both during delivery and throughout O&M.

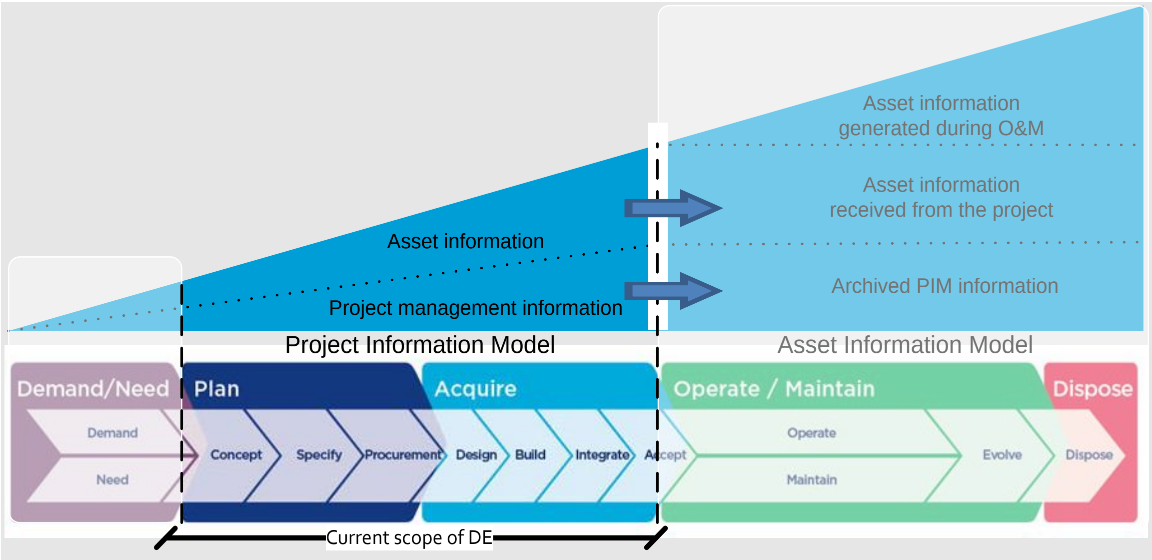


Figure 12 – Development of the Asset Information Model

4.4 Project information

4.4.1 Project Information Requirements (PIR)

As illustrated in Figure 12, the PIR are composed of two parts:

1. Project management information requirements – the information that is required to undertake project management, governance and assurance functions, but archived at asset handover.

5. Project asset information requirements – information about the asset and asset systems that is required for configuration management, engineering assurance, and to demonstrate business and system requirements traceability/compliance. This information is built-up over the life of the project. A defined subset of data is transferred from the PIM at asset handover into the AIM.

The PIR for TfNSW projects are specified in this DE Standard and defined in the project contract, including the DEXP and PDS (see Figure 13).

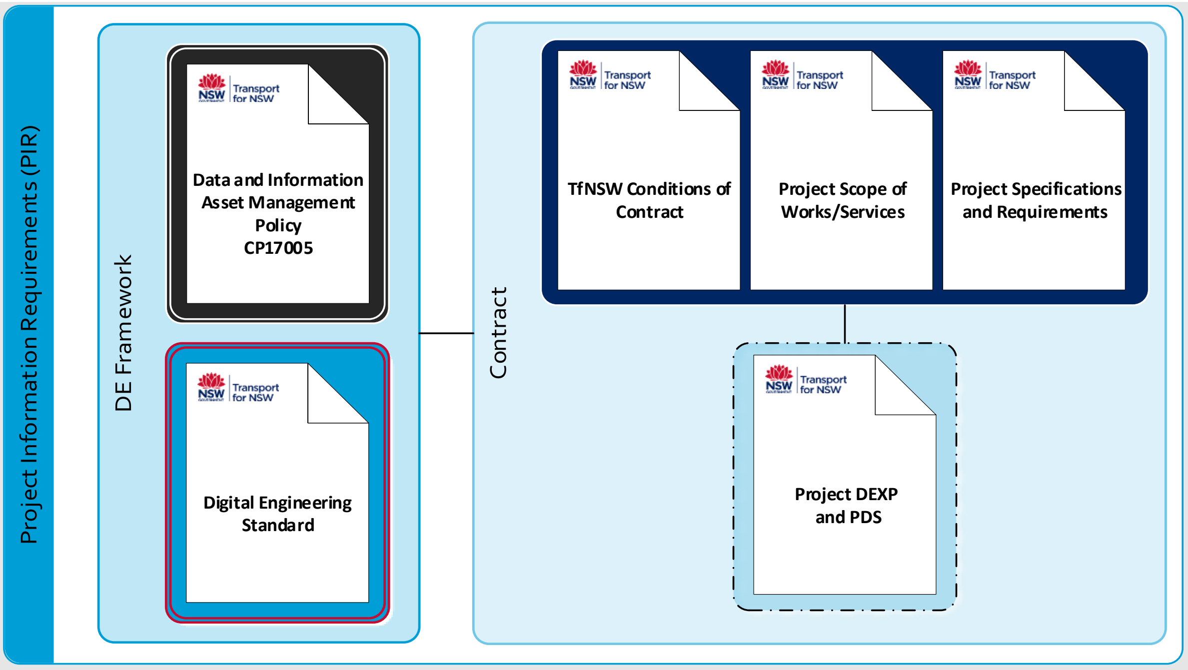


Figure 13 – Project information requirements defined within contract and standard documents

4.4.2 Project Information Model (PIM)

The PIM contains all documentation, non-geometric (data) and geometric information (engineering drawings and models) used and produced during the planning, design and construction phases of the project. The systems used to structure and store this information are referred to collectively as the Common Data Environment (CDE). See Section 8 for further information regarding the CDE.

The information contained within the PIM includes all deliverables identified in contract documentation, including asset owner standards and any other information relied on or used by the contractor for the development and delivery of the project.

All project and asset information remains within the PIM until the TfNSW project transitions into the O&M phase at asset handover. On handover of the physical asset and appropriate associated information, the PIM relevant to O&M is transferred and further developed by the Operator and Maintainer during the O&M phase. Those sections of the PIM that are not required for the O&M phase are archived for future reference.

Successful handover of information from the project delivery phase PIM to the AIM requires an alignment/mapping of asset information metadata in the DE asset register to project information metadata, for example the update from project locations to asset locations. This concept and the requirements for data formats are provided in DMS-ST-207 – *Digital Engineering Standard, Part 2: Requirements*.

4.4.3 Project information model deliverables

The PIM consists of two parts: the project management information that is archived at the end of the project, and the project asset information that is handed over to O&M.

Examples of the types of project management information produced include:

- all design engineering information including CAD, BIM and GIS information
- temporary works information
- time and scheduling information
- cost management data
- registers such as risk registers, issue registers, interface registers
- safety management information such as Safe Work Method Statements (SWMS), hazards
- environmental information such as key constraints and conditions of approval
- project management data
- all other relevant project information.

Examples of project asset information that is transferred to the AIM at asset handover includes:

- handover DE Asset Register
- all As-Built engineering information including CAD, BIM (3D models) and GIS information
- quality assurance information such as Inspection and Test Plan (ITP) and manuals
- warranties
- residual risks and hazards
- actual delivery costs by asset type and location
- other relevant asset management information for operations and maintenance.

For project-specific asset handover information refer to project contract and TfNSW individual asset requirements including:

- T MU AM 01014 ST – *Asset Information Handover Requirements*
- T MU AM 02001 ST – *Asset Information and Register Requirements*
- ILC-GEN-TP0-901 – *Asset Acceptance Technical Procedure*

The success of DE on a project is largely dependent on how disciplined the team is at managing change within the PIM, and ensuring its data is structured consistently and in accordance with the project information requirements (which incorporate the plan/acquire stage asset information requirements).

4.5 Exchange information requirements

The Exchange Information Requirements (EIR) specify the production, management and characteristic requirements of information to be submitted under a particular contract. These requirements detail deliverables and standardise information characteristics such as:

- source
- file format
- file size
- data structure
- data security.

To integrate with the TfNSW commercial framework, the EIR provided to a contractor are included across several key contract documents. These include the services/works brief, management requirements, the DMS-ST-207 – *Digital Engineering Standard, Part 2: Requirements*, the project specific DEXP template (based on DMS-FT-532) and associated Project Data Schemas (PDSs). See sections 5 and 5.2 for more information.

5 Project data management

5.1 Overview

Project data management is the discipline of managing the structured data that is project-critical. Data management includes the process of structuring, specifying, organising, storing, maintaining, transferring and managing the integrity of the data collected and created by the project. It encompasses the sharing of data with all relevant project stakeholders. The discipline extends to the management and configuration of relevant IT systems that support the relevant types of project data.

The requirement for the governance of project data exists so that the data and information produced within and between projects can be federated, interrogated, verified, analysed and reused. Digital Engineering increases the demand for project data management due to the significant increase in the volume and complexity of project data, as well as the reliance on this data for accurate and informed decision-making.

Both TfNSW and the contractor have a role in achieving good data governance during a project, and both parties can benefit as consistent, structured data enables collaboration, automation, interoperability, and visualisation, which assist with safe and assured project delivery.

As all personnel engaged during a project have a role in creating and/or using data, it is important that everyone understands the data management approach, including requirements for data creation, validation, assurance and change control procedures.

TfNSW DE-enabled projects utilise the Project Data Building Blocks (PDBB) tool and the Project Data Schemas (PDS) to provide a centralised, visible and controlled environment for the management of project data. The responsibility and the processes to update the PDBB and PDS are documented in the TfNSW Project Management Plan (for the TfNSW project team) and the project DEXP (for the contractor team).

A key outcome of using the PDBB is alignment and traceability between PIM and AIM (see Figure 14).

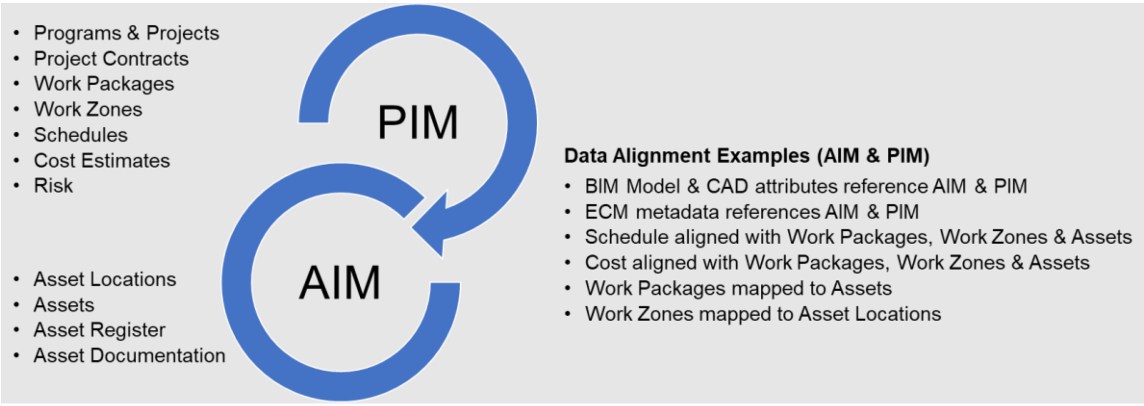


Figure 14 – Project Information Model and Asset Information Model alignment examples

To maintain the alignment between PIM and AIM, the DE framework provides a centralised change process for managing key project data using the PDBB, and then publishing this data for use by the contractor through the PDS; this process is further explained in the following sections.

5.2 Project Data Building Blocks (PDBB)

The PDBB is a collective name for the structured data being utilised by the project team in the creation of data and information deliverables.

Figure 15 – The Project Data Building Blocks (PDBB)

The PDBB (Figure 15) is made up of:

- **Standard TfNSW Building Blocks** – TfNSW governed and version-controlled master data that is common to all projects
- **Project Specific Building Blocks** – project-created data that follows specified data structures and leverages the standard TfNSW master data. A central part of this data includes asset-related information which follows a classification and referencing approach outlined in Section 6.

The TfNSW project team uses the PDBB template (DMS-FT-548) to manage the project data. Once the project data is established in the PDBB, it is leveraged by multiple teams on the project. The creation of individual project DE deliverables is governed by data requirements specified in the PDS which are initially seeded from the PDBB.

Due to the critical nature of the PDBB and their role in the success of DE within the project and across TfNSW, TfNSW mandates that for Digital Engineering projects:

- the TfNSW project team, or delegated representative, must create, manage and maintain the PDBB (see DMS-FT-548 – *Project Data Building Blocks Template*) throughout the life of the project
- alignment of PDS with the PDBB must be maintained throughout the life of the project
- changes to the PDBB must be confirmed in collaboration with TfNSW.

The project procedures for control and governance of the PDBB and change requests is to be confirmed in the project DEXP. Refer to DMS-ST-207 – *TfNSW Digital Engineering Standard, Part 2: Requirements*, v4.1, Section 4, for the project data management requirements.

Figure 16 illustrates the key data and relationships that the PDBB support.

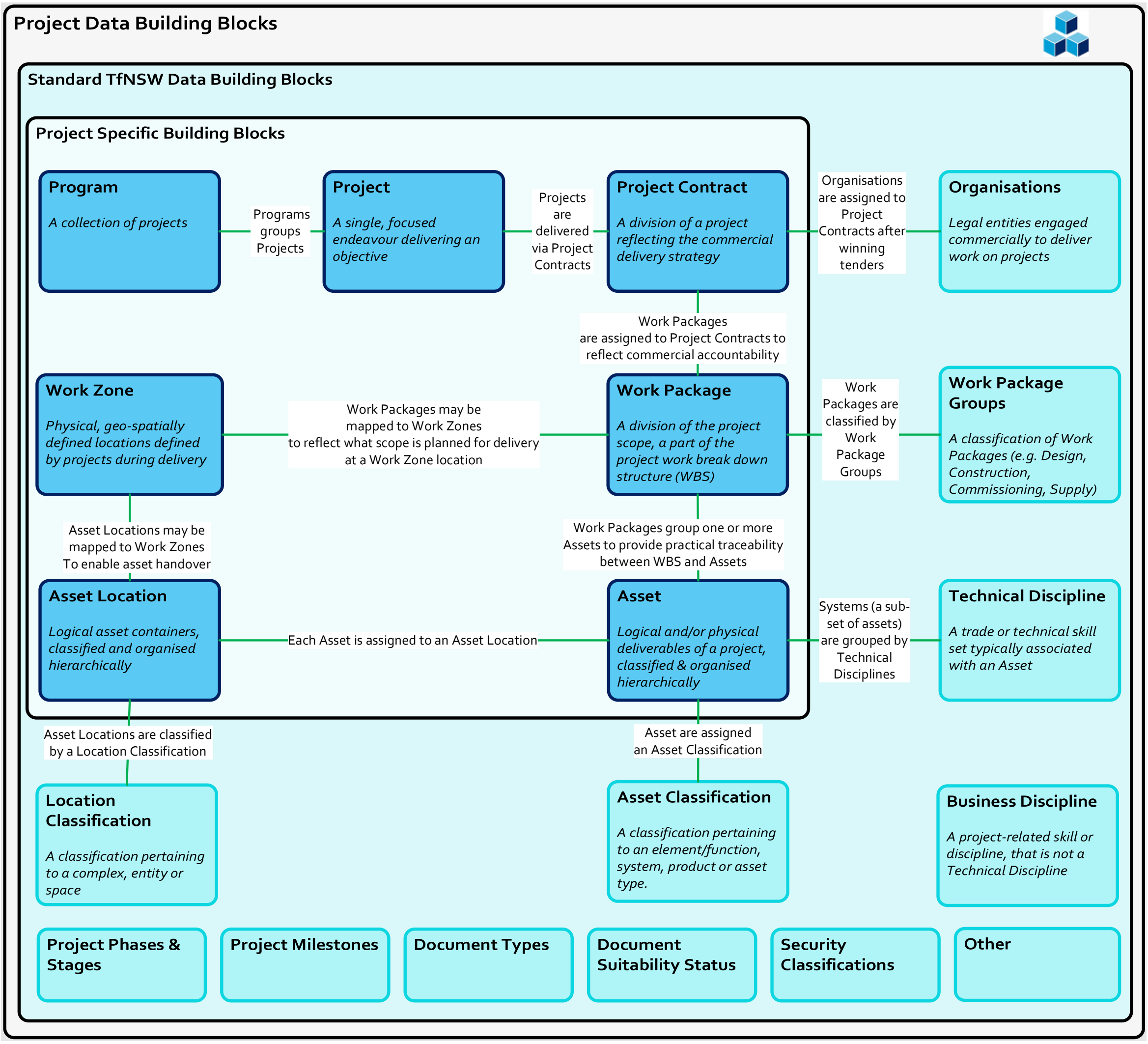


Figure 16 – Project Data Building Blocks – key data and relationships

5.3 Project Data Schemas (PDS)

The PDS contain the definition for the structure of the data required to exchange information between project participants and across project phases, specific to the discipline deliverable. The PDS also contains appropriate data from the PDBB which ensures that common project data values are utilised to achieve data alignment across disciplines.

Each discipline has its own requirements for information and as such, there is a specific PDS for each project discipline. The PDS may also vary based on current technology limitations and may be modified to enable PDBB to be applied in a practical and user-friendly way. Currently disciplines for which PDS have been defined include systems engineering, survey, CAD, BIM, ECM, visualisation, GIS, time, cost, and asset data.

It is critical that any common information represented within the various PDS is coded and/or described in the same way (that is, utilises the same classification and referencing).

Changes to data standardisation and configuration, defined by the PDS, may have wide-reaching implications. The project data does not exist in isolation but is part of the wider project, agency and cluster PIM, AIM and OIM. For this reason, any proposed changes to the PDS must be approved by TfNSW such that the accepted changes can be incorporated into the PDBB and cascaded to all interfacing datasets and systems.

For example, any new codes, variation in scope or design decision that changes or develops the standard or project specific building blocks, must be captured in the PDBB and pushed out to all project PDS (see Figure 17). Maintaining this alignment also assists with progression of the project through the CMF Baseline and Review Gates.

The relationships between the PDBB, incorporating classification, and the PDS are illustrated in Figure 17.

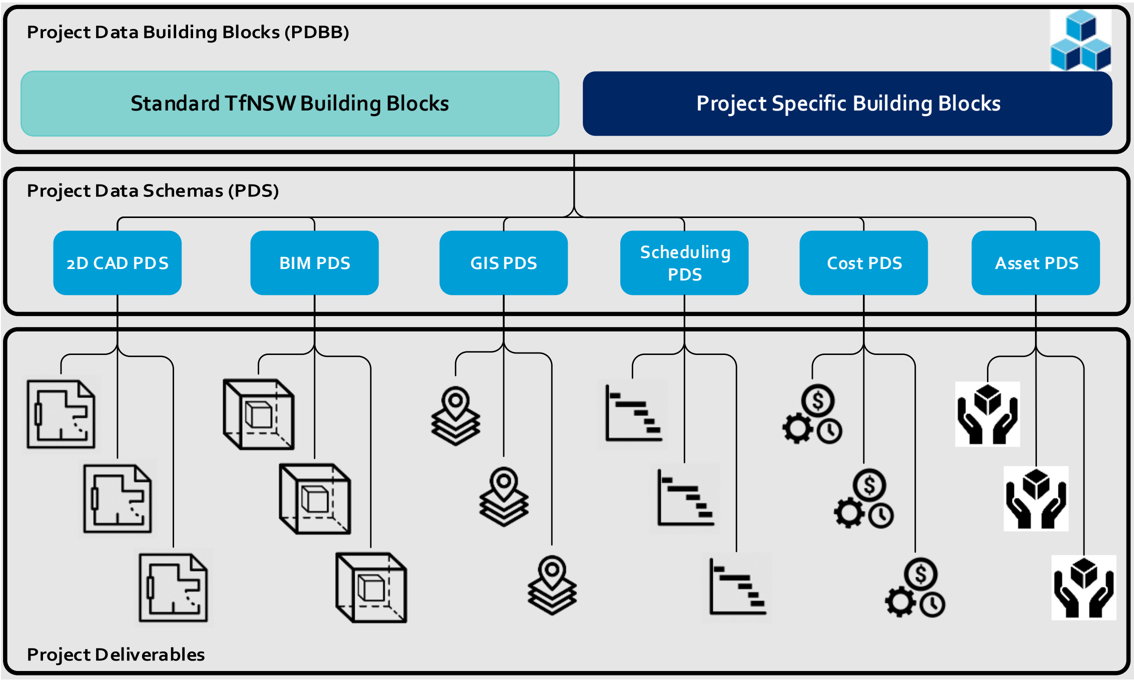


Figure 17 – Project Data Building Blocks–Project Data Schemas relationship

The PDS are populated with project-specific data by TfNSW and provided to the contractor as appendices in the DEXP template. The contractor is provided with the flexibility to request changes to the PDS proposed by TfNSW.

The contractor is also able to add additional granularity below the coding structures provided by TfNSW, however, the new codes must roll-up to the standardised structures provided by TfNSW to enable the satisfaction of PIM and AIM requirements.

6 Data standards

6.1 Overview

The principles of DE are underpinned by consistent data standards and utilising open international standards where they are available. For TfNSW DE-enabled projects, standardisation of data associated with where the works are taking place (location), what infrastructure is being created or changed (asset) and who is responsible for the works (discipline) is fundamental information that must be associated with each data-set. This section provides the key concepts the DE framework uses to achieve this: classification, referencing and work packages.

6.2 Classification and referencing

6.2.1 Overview

For DE projects, all data must be prescribed with two essential attributes:

- classification
- reference.

This allows project data to be identified, analysed, interpreted correctly, as well as be managed, federated, and stored both within project and organisational contexts.

- Classification refers to the application of an appropriate 'type-of' attributes to an item in the information model.
- A reference is a 'name' and/or an 'identifier' and is essential to uniquely identify each item within the information model.

Standardised classifications and defined references are fundamental components of data within the PDBB. Classifications and references within the PDBB are maintained centrally and applied appropriately to any data or information deliverable created during the project via the PDS.

Specific classification and referencing are applied to the Asset Location, Asset and Discipline with these classification relationships illustrated in Figure 18.

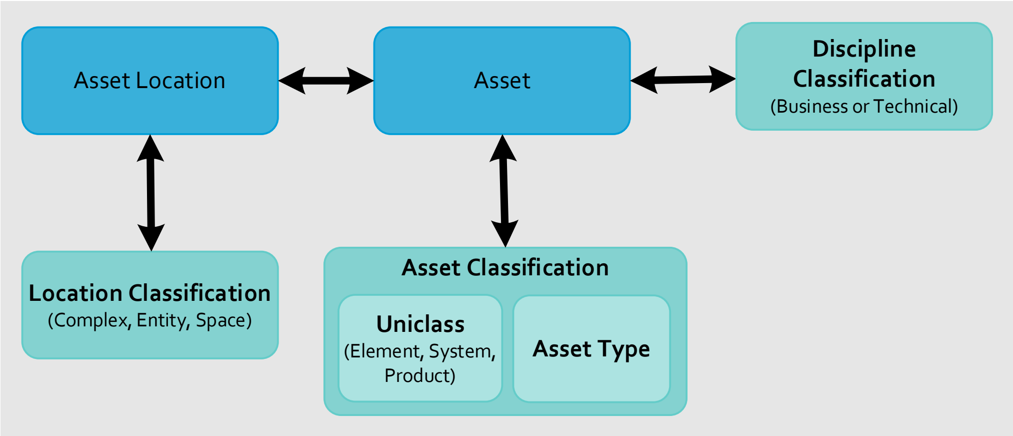


Figure 18 – Classifications applicable within the TfNSW Digital Engineering Standard

The DE framework supports the utilisation of multiple standard classification systems (including international standards such as Uniclass and TfNSW specific standards) within the broad framework outlined below:

- **Location Classification** is the classification of logical asset containers and/or asset locations and enables grouping of assets by their physical proximity, interconnection and/or where activities take place.
- **Asset Classification** is the classification of assets all various levels of granularity and/or specificity including element or function, system and product. Asset type allows for grouping of assets for the purpose of internal business reporting and benchmarking.
- **Discipline Classification** enables assignment of responsibility or grouping for an activity, asset or document by the business or technical discipline.

Table 4 provides a summary of classification standards adopted by the DE Standard.

Table 4 – Classification standards

Classification	Sub-classification	Standard	Definition
Asset Location Classification	**Complex**	Uniclass Complexes (Co)	Complexes are top level asset containers that describe the overall collection of assets. Complexes are further divided into entities and spaces. Transport examples: • Heavy Railway Network • Road Network

OFFICIAL

Classification	Sub-classification	Standard	Definition
Asset Location Classification	**Entity**	Uniclass Entities (En)	Entities are discrete asset containers such as a building, bridge or tunnel. For linear assets this includes rail and road corridors.
Asset Location Classification	**Spaces or Locations**	Uniclass Spaces/Locations (SL)	Spaces or locations are designated areas where an activity or function takes place. This level of classification is also utilised for dividing the asset into suitable sections. Transport examples: • Junction • Stop • Road lane
Asset Classification	**Element or Function**	Uniclass, Elements/Functions (EF)	Elements are the main components of a building (floors, walls and roofs) or of a structure, for example a bridge foundations, piers and deck. Functions are the building services to be provided and managed. Transport example: • Abutments (of a bridge) • Barriers • Lighting
Asset Classification	**System**	Uniclass Systems (Ss)	Either one or more Systems are collected to describe an element or a function. Systems are collections of products that work together to perform a specific function, for example, a drainage system may include pipes, pits, grates, channels, access chambers, geotextile, aggregate.
Asset Classification	**Product**	Uniclass Products (Pr)	Products are the individual items sourced and supplied to build up a System. Transport examples include: • Conductor rails • Rail track tie bars • Hot-rolled asphalt (HRA) surface courses and slurries

Classification	Sub-classification	Standard	Definition
Asset Classification	**Asset Type**	TfNSW defined	An Asset Type is a TfNSW defined code which provides an alternative asset classification that is independent of Uniclass. As the Asset Type is an internal standard, it allows the business to gain added flexibility to group assets specific to TfNSW that are not possible with Uniclass. For example, to group Uniclass codes or add more specificity. Asset Types are human-readable and structured in a rigid hierarchy focused around Maintenance Managed Items (MMI). They may also be used for internal benchmarking and reporting of time, cost, quality, performance, and so on.
Discipline Classification	**Business**	TfNSW defined	Business Discipline classification enables the grouping of management, indirect or overhead activities and deliverables into organisational or manager codes.
Discipline Classification	**Technical**	TfNSW defined	Technical Discipline classification enables the grouping of technical trades that are predominantly associated with specific assets.

6.2.2 The use of Uniclass

TfNSW has chosen to adopt Uniclass (developed by the National Building Specification (NBS)) for classification of assets and locations during the Plan-Acquire stages. The choice to adopt Uniclass follows comprehensive research and analysis of available classification systems, industry-wide, against ISO 12006.2:2015.

The key benefits of adopting an industry standard like Uniclass includes:

- **industry adoption** – access to skilled individuals who are familiar with the Uniclass classification system across industries and jurisdictions, and alignment with the Rail Industry Safety and Standards Board (RISSB) and Austroads recommendations
- **supply chain integration** – ability to author and communicate design and construction requirements with industry suppliers in a consistent and accepted manner
- **standard library of objects** – ability to leverage component models that are already attributed with classification data

- **standard development and integration** – automatic access to the improvement of the standard over time, including efforts to align other industry standards (for example IFC, railML, ICMS, NRM, GS1, GML)
- **quality control** – improved quality control of designs with ability to check content for consistency and completeness
- **software compatibility** – Uniclass is a DE-compatible classification standard which is readily supported by major software vendors. The ability to leverage software tools that are compatible with the standard improves the ease of adopting the standard.

TfNSW continues to engage in ongoing work with NBS to improve and develop this standard for Transport use. Refer to the **NBS website** for further information in relation to Uniclass.

TfNSW stakeholders continue to collaborate to improve the use of classification for best appropriate practice and to facilitate TfNSW business functions. For more information regarding TfNSW's adoption of Uniclass, refer to DMS-SD-124 – *Application of Uniclass for Transport*.

For assistance with the application of Uniclass in your project, seek guidance from your DE manager or contact the DE team at **Digital.Engineering@transport.nsw.gov.au**.

6.3 Location containers

To assist with planning, design, delivery and management, DE-enabled projects utilise two location concepts: Asset Location containers and Work Zone containers. The use of additional location attributes/information, for example spatial data, is addressed within the PDS and DMS-ST-207 – *TfNSW Digital Engineering Standard, Part 2: Requirements*.

DE-enabled projects adopt Asset Location containers defined by the TfNSW asset owner/custodian (for example, a station, road, rail corridor, bridge) to enable asset handover into the maintenance phase. An additional container grouping based on work methodology is also required to facilitate design and/or construction. These Plan/Acquire-stage specific location containers are known as Work Zones. Table 5 provides a comparison of the use of Work Zones versus Asset Locations.

Table 5 – Comparison between Work Zones and Asset Locations

Work Zones	Asset Locations
• Work Zones are created from a project delivery perspective	• Asset Locations are created to allow for a holistic Transport network/asset owner view

OFFICIAL

Work Zones	Asset Locations
• Work Zones have spatial geometry • Work Zones are orthogonal to Asset Locations as they may encompass multiple Asset Locations (for example, intersection work zone where light rail and road asset locations exist)	• Asset Locations may be logical/functional asset containers or may also be related to spatial geometry
• Work Zones are not classified (not possible when one work zone covers multiple asset locations) • However, Work Zones may be part of a Work Zone group (for example, design, construction)	• Asset Locations are classified with a suitable Asset Location classification code to enable grouping of locations that are the same 'type'
• Work Zones are fluid and may be re-defined during the project life cycle. Hence, there is a temporal aspect to Work Zones	• Asset Locations remain static unless changes to the asset configuration/design are introduced during the project. This is more common in greenfield projects
• Work Zones are never referenced in an DE Asset Register • Work Zones references may be used in schedule, cost, risk, breakdown structures, and so on	• Asset Locations are referenced in the DE Asset Register
• Work Zones are controlled and governed at a project level	• During the Plan/Acquire phase Asset Location classification utilises Complexes, Entities and Spaces within Uniclass • Asset Location referencing that is assigned to the classification is governed at a TfNSW level (see DMS-ST-207, section 4.2.1, v4.1)
• When planning 'job/QA lots', Work Zones are a better fit and required for practical grouping of assets and work packages • These lots often include assets from multiple modes (for example, paving, earthworks, concrete pours) • QA evidence may be associated with a Work Zone	• Work Zones can be mapped to one or more Asset Locations via the relationships in the PDBB, to enable attribution of asset location metadata against asset information at asset handover
• Work Zones are also useful to identify when a contractor has control over a work zone. There may be a contractual tie in to Work Zones.	

6.3.1 Asset Location classification and referencing

During the Plan and Acquire stage, all significant Asset Locations are identified and an appropriate location classification is assigned. This is done to reflect the required asset containers needed to allow for an orderly organisation of the required asset networks and delineation of project scope.

All Asset Locations are assigned a unique location reference. For any existing Asset Locations existing references must be preserved.

The DE Standard requires that asset locations are organised hierarchically to provide contextual relationships between asset locations. A hierarchical structure is flexible to allow maximum expression of key asset location-to-asset location relationships.

With location classification hierarchies, a key convention is to identify the transport network (Complex) at the top of the hierarchy, followed by Entities and Spaces/Locations reflecting real-world topographical relationships.

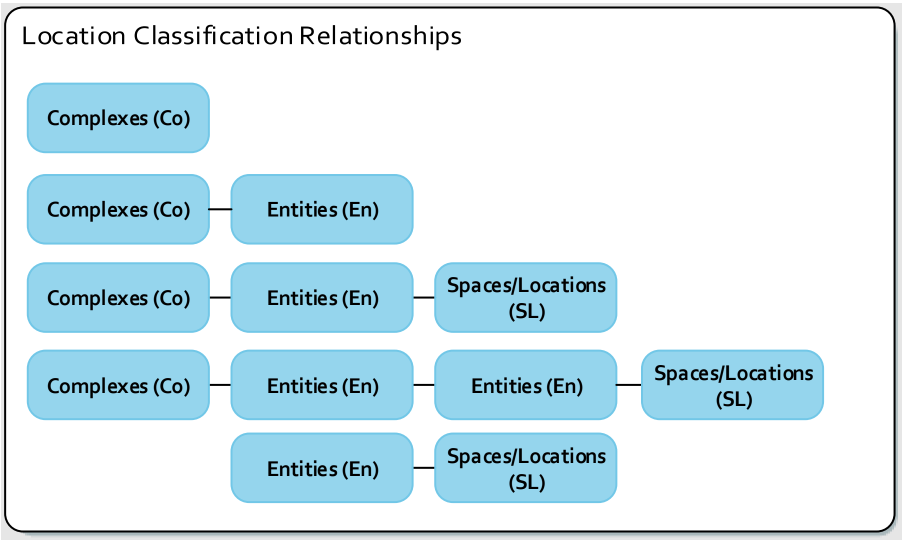


Figure 19 – Possible project location classification relationships

Once asset locations are defined (classified and referenced), they can be used to group assets.

The TfNSW DE framework requires the use of the Uniclass Complexes (Co), Entities (En) and Spaces/Locations (SL) classification tables when classifying asset locations during project delivery (Figure 19).

All locations within the Transport network as a minimum must also be associated with a parent network code to differentiate the mode. See Table 6 for the alignment of classification with the TfNSW references.

Table 6 – TfNSW Complexes

Uniclass Classification Code	Uniclass Location Title	Asset Location Code	Asset Location Description
Source: Uniclass, Complexes Table	Source: Uniclass, Complexes Table	Source: T MU AM 01007 TI (Jan 2021), 1. Network, Mode and Form tab, Transport Network table, Network Codes	Source: T MU AM 01007 TI (Jan 2021), 1. Network, Mode and Form tab, Transport Network table, Network Codes
Co_80_50	**Railway complexes**		
Co_80_50_35	Heavy rail complexes	HRS	Heavy Rail-Sydney
Co_80_50_35	Heavy rail complexes	HRC	Heavy Rail-Country
Co_80_50_45	Light rail complexes	LRS	Light Rail-Sydney
Co_80_50_45	Light rail complexes	LRP	Light Rail-Parramatta
Co_80_50_45	Light rail complexes	LRN	Light Rail-Newcastle
Co_80_50* * to be further defined	Railway complexes* * to be further defined	MRS	Metro Rail-Sydney
Co_80_35	**Road complexes**	-	-
Co_80_35_75	Road networks	RDR	Road-Regional
Co_80_35_75	Road networks	RDS	Road-State
Co_80_35_75	Road networks	RDL	Road-Local
Co_80_35_10	Bus route networks	RDR	Road-Regional Legacy (Apr 2019) codes: • BU-B Buses-Blue Mountains • BU-C Buses-Central Coast • BU-H Buses-Hunter • BU-I Buses-Illawarra • BU-R Buses-Regional & Rural
Co_80_35_10	Bus route networks	RDS	Road-State Legacy (Apr 2019) codes: • BU-S Buses-Sydney
Co_80_35_10	Bus route networks	RDL	Road-Local
Co_80_70	**Marine and waterways transport complexes**	-	-
Co_80_70_96	Waterway ferry complexes	MAS	Maritime-Sydney Legacy (Apr 2019) codes: • FE-S Ferries-Sydney

Uniclass Classification Code	Uniclass Location Title	Asset Location Code	Asset Location Description
Co_80_70_96	Waterway ferry complexes	MAR	Maritime-Regional Legacy (Apr 2019) codes: • FE-N Ferries-Newcastle

Intricate asset Entities (En) may have child Entities (En) within them. For example, a Station entity can have platform entities or a Road entity can have bridge entities. Likewise, Spaces (SL) can have child Spaces (SL), for example, Level spaces can have Room spaces or Carriageway spaces can have Lane spaces.

As a project progresses, the specification of locations becomes more defined. The project location classification is usually specified much earlier in the project lifecycle than asset classification. Often, the Complex (Co) and Entity (En) is known in the earliest demand/need or planning phases. The Entity would then be further specified into Spaces (SL) for example during the concept or preliminary design phases.

The location classifications and references defined for a project, and their relationships, are centrally managed in the Location List within the PDBB (DMS-FT-548 – *Project Data Building Blocks Template*). Further guidance and examples of the application of classification are provided in DMS-SD-124 – *Application of Uniclass for Transport*.

6.3.2 Work Zones

The main purpose of Work Zones is to support delivery planning and execution.

During the Plan and Acquire phases of a project, the identification of where work is being conducted may often be made without the requirement to adhere to logical asset locations and their strict classifications. For example, the need to conduct work at an intersection which contains a portion of a road network as well as a section of a light rail corridor requires a single reference to a location. References to two asset locations, whilst useful for context, might not be practical when planning project work.

Work Zones provide a mechanism to define geo-spatial locations (can be 2D and/or 3D) which can be designated a unique Work Zone reference. Work Zones can be organised into Work Zone groups to accommodate various Work Zone sets. Work Zone locations can be organised hierarchically to reflect the segmentation of Work Zones into child Work Zones (or sub-work zones).

Figure 20 illustrates an application of the Work Zone concept on a project. In this case, the project used ‘Area X.Y’ as the naming convention for their Work Zones with a two-level hierarchy of Work Zones.

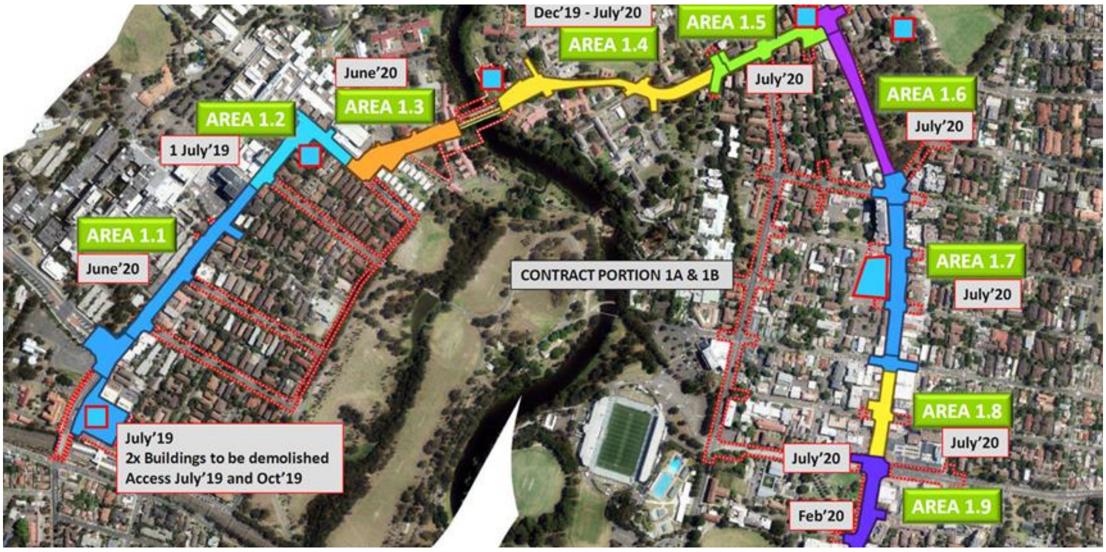


Figure 20 – Work Zone example

Since Work Zones definitions are geo-spatial, they can be overlayed and intersected with geo-referenced BIM models. When this is done, the result is a segmented BIM model. Model segments can produce segmented quantities. For linear assets, this allows for segments of assets to be correlated to Work Zones thereby providing an opportunity to report status in a flexible and structured manner.

Work Zones may, therefore, be useful to answer the following types of business questions during projects:

During planning:

- Where will project work be conducted? What is the project boundary?
- How do we segment a linear asset into manageable chunks? What work is to be conducted? (Relationship between Work Zones, Work Packages and Assets)
- Who has control of the location and when (for example possession planning or determining contractor area of control)?

During execution: (progress tracking)

- How is the project progressing in this location (work zone)?
- What quantities have been delivered?
- Does the payment claim correspond with work completed?

6.4 Assets

6.4.1 Overview

To assist with planning, design, delivery and management, DE-enabled projects may utilise multiple asset classification systems. As DE transverses disciplines as well as transport modes, there can exist a need to comply with multiple classifications. For example, for quantity take-off, the use of the International Cost Measurement Standard (ICMS) or New Rules of Measurement (NRM) and, for example, utilities, compliance with Classification of Subsurface Utility Information (AS5488). Additionally, projects are required to comply with existing TfNSW internal classifications and TfNSW cost control procedure. The use of Uniclass provides a consistent classification baseline against which other classification systems can be translated. The use of classification, asset type and referencing are foundational to consistently defining the assets affected by project works across discipline deliverables.

6.4.2 Asset classification and referencing

6.4.2.1 Overview

The DE Standard requires that assets are organised hierarchically to provide contextual grouping that reflects how assets come together to deliver a function. A hierarchical structure is flexible to allow maximum expression of key asset-to-asset relationships.

With asset classification hierarchies, a key convention is to define Elements/Function at the top of the hierarchy, followed by Systems and then Products. Examples of possible asset hierarchies are illustrated in Figure 21.

The classification systems currently applied to the assets are:

- Uniclass
- TfNSW internal standards, primarily T MU AM 02002 TI – *Asset Classification System.*

Additional to classification, each instance of asset is assigned a unique project reference. For any existing assets which are being modified by the project, existing references must be preserved.

See Section 6.2 for more information on how and why the different classification systems are used and for discussion on referencing.

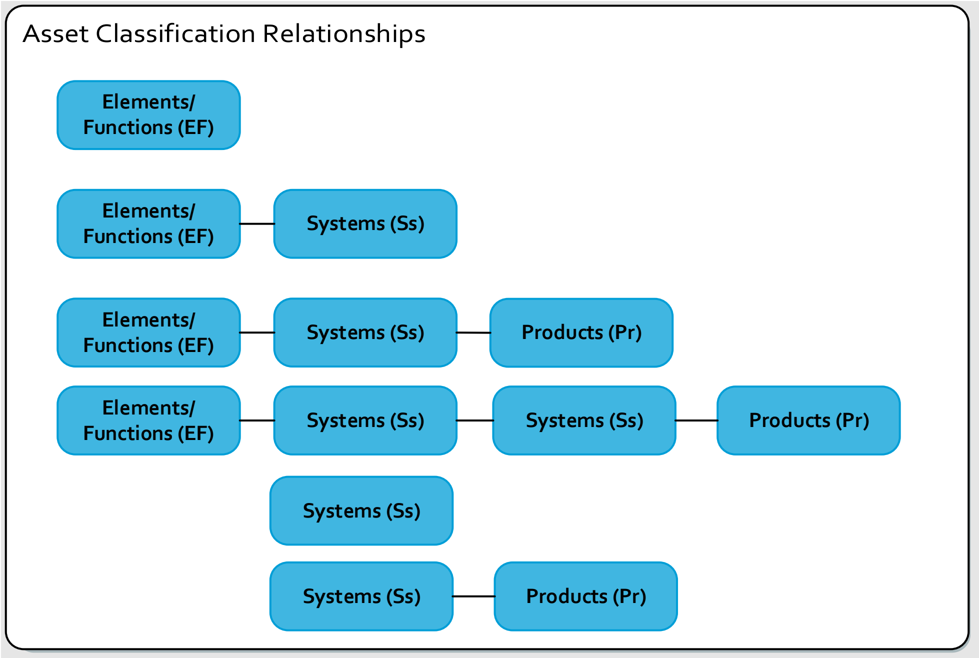


Figure 21 – Asset classification relationships

The PDBB are progressively updated as further classifications and references are defined for the project during each design phase.

6.4.2.2 Uniclass

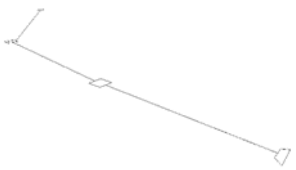
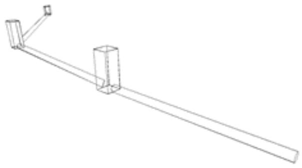
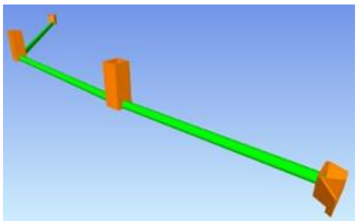
During the Plan and Acquire stages, individual assets are classified using the Uniclass tables including Elements/Functions codes (EF), Systems (Ss) or Products codes (Pr).

As the Systems Requirements Specification and project scope are developed, these can be aligned with Uniclass element/function (EF) codes and systems codes (Ss). During detailed design products (Pr) are specified and associated with a system (Ss) and parent element/function (EF). These relationships and the development of classification is illustrated in Table 7.

Intricate asset systems can have child systems associated to them; for example, a Monitoring system (Ss_75_40_53) on a platform may have child systems of both a Surveillance system (Ss_75_40_53_86) and a Train dispatch CCTV system (Ss_75_40_53_90). Currently, these intricate asset hierarchies must be managed outside of many model authoring tools. The DE framework proposes that these hierarchies are managed in the Asset List, included in the PDBB (DMS-FT-548 *Project Data Building Blocks Template*).

Further guidance and examples of the application of asset classification are provided in DMS-SD-124 – *Application of Uniclass for Transport*.

Table 7 – Example Asset Classification aligned with CMF Baseline and Review Gates

CMF baseline and review gates	Concept baseline	Preliminary design baseline	Approved design baseline
Design development	LOD 100 	LOD 200 	LOD 300 
Classification development	**EF_50** **Waste disposal functions** Ss_50 Disposal systems	**EF_50_35** **Below-ground drainage collection** Ss_50_35 Surface and wastewater drainage collection systems Pr_65_52 Pipe, tube and fitting products Pr_20_93 Unit structure and general products Ss_50_70_85 Sustainable drainage systems (SuDS) Pr_20_85 Support and restraint products Pr_25_93 Unit skin products	**EF_50_35** **Below-ground drainage collection** Ss_50_35_82_73 Road drainage systems Pr_65_52_01 Access and inspection chambers and gullies Pr_65_52_07 Below-ground and pressure drainage pipes and fittings Pr_20_93_37 Headwall and swale inlet products Ss_50_70_85_58 Open channel conveyance systems Pr_20_85_28 Erosion control and breakwater products Pr_25_93_60 Paving units

6.4.2.3 Asset Type codes

To complement the Uniclass classification, a TfNSW defined type code is also utilised during project delivery. Where further definition is required, the Type code is supported with an Asset Type Configuration code. Alignment of Uniclass to Asset Type codes is provided in DMS-SD-141 – *Master Classification Library*. Use of the TfNSW code provides alignment with TfNSW data standards (see DMS-ST-207) and may also be used to facilitate the design process where there are multiple types/configurations and/or provide alignment with the Asset Stewards' enterprise asset management systems, facilitating handover.

Table 8 – Example of Asset Type codes

Asset Type Code (Source: T MU AM 02002 TI)	Asset Description	Uniclass Asset Code	Uniclass Asset Title	Asset Type Configuration Code (Project defined)
EL	Electrical	EF_70_30	Electricity distribution and transmission	
LVDS	LV Distribution System	Ss_70_30_45_45	Low-voltage distribution systems	
CABL	EVA insulated cable	Pr_65_70_48_13	Cross-linked EVA-insulated single-core non-sheathed cables	C1
CABL	Silicone insulated cable	Pr_65_70_48_14	Cross-linked silicone rubber-insulated single-core cables	C2
CABL	PVC insulated cable	Pr_65_70_48_32	Flexible cables with thermoplastic PVC insulation	C3
CABL	LSHF cable	Pr_65_70_48_88	Thermosetting-insulated armoured fire-resistant (LSHF) cables	C4

6.5 Discipline classification

Discipline classification enables the grouping of activities or assets by an organisational grouping, dependent on the person or group of persons responsible for the activity or asset at a defined time in the asset life cycle. The discipline classification is categorised as either:

- Business Discipline
- Technical Discipline.

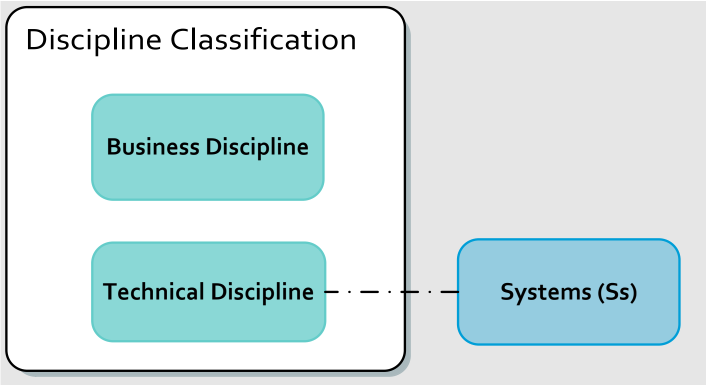


Figure 22 – Discipline classifications

Refer to DMS-ST-207 – *Digital Engineering Standard, Part 2: Requirements* for TfNSW's discipline codes and requirements for the application of Discipline classification.

The DE Framework proposes that the Technical Disciplines are associated with assets classified as Uniclass Systems (Ss) in the PDBB (DMS-FT-548). See Figure 22.

6.5.1 Business discipline

Business Discipline classification enables the grouping of management, indirect or overhead activities and deliverables into organisational or manager codes. It is recommended that this hierarchy be based on the recognised industry qualification (for example, Transport Planning, Quantity Surveying), to help facilitate workflows in content management, Work Breakdown Structure (WBS) in schedules and Cost Breakdown Structure (CBS) in cost estimates.

The business discipline should be a hierarchy that allows information to be coded to a business unit, such as safety, property, environment and planning. If needed, each of these high-level business disciplines can be broken down into practical sub-disciplines to aid in project delivery.

6.5.2 Technical discipline classification

This is a TfNSW developed classification required to enable the grouping of several Uniclass Systems into a practical Design Package (for example, Civil, Electrical, Communications) and often forms part of the Work Package grouping in the cost codes and schedule WBS during the design and construction phases.

Note: The technical discipline classification may be at a high level during the planning and preliminary design phases (Civil, Electrical, and so on), however, become more granular (sub-disciplines) at the detailed design stage (for example, Civil-Earthworks, Civil-Stormwater Drainage, Electrical-High Voltage, Electrical-Overhead Traction).

The adoption of disciplines by the project is confirmed in the PDBB and the Technical Discipline alignment with the System classification is also managed within the PDBB.

Further guidance and examples of the application of discipline classification is provided in DMS-SD-124 – *Application of Uniclass for Transport*.

6.6 Work Packages

Projects typically develop a project work breakdown structure (or WBS) as part of the project planning process. A work package is an individual element of the WBS that defines a discrete deliverable and is usually combined with Asset Classification (usually Elements/Functions and Systems), Technical Disciplines and Work Zones to create practical grouping and sorting in the WBS.

A key business objective of the DE Standard is to leverage structured data to improve transparency of project information. This standard provides specific recommendations on how a project WBS needs to be enhanced to drive improved understanding of the ‘scope’ of work packages.

As project schedules are typically used to reflect a process-oriented view of the project WBS, work packages in a schedule which are associated with the design, or construction, or the commissioning of assets are often referring to the same assets or group of assets, albeit multiple times, at different phases of a project.

These work package references in schedules, however, are not able to accurately reflect which assets are assumed to be in scope making validation and traceability between schedules and BIM models, for example, difficult.

In Release 4.1 of the DE Standard, the PDBB provide a mechanism to associate Work Packages with Assets to clearly establish a link between a unit of work and the resultant assets that this unit of work will deliver.

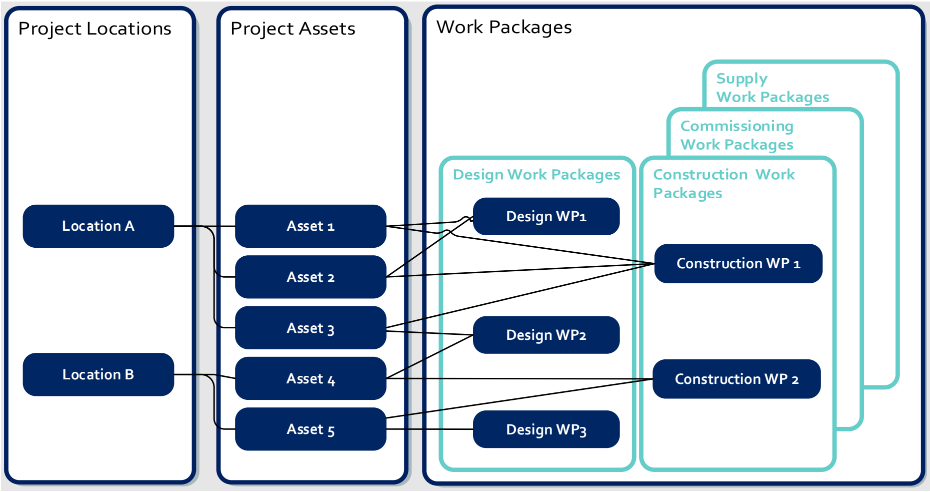


Figure 23 – Relationship between Work Packages and Assets

As depicted in Figure 23, there is flexibility to group assets in multiple ways to allow for Work Packages in the design phase, for example, to group assets independently to the construction phase. This flexibility is defined and managed using the PDBB.

There is also a requirement to group non-asset related work related to management deliverables. There are, therefore, five Work Package Groups which classify Work Packages as (i) Design, (ii) Construction, (iii) Commissioning, (iv) Supply, and (v) Management.

7 Collaboration

7.1 Overview

Effective collaboration by the project teams is essential for realising the benefits of DE; both between TfNSW and the contractor, and within each contractor team. The tools, mechanisms and individual responsibilities that will enable collaborative working, including how, where and when project information will be shared must be communicated clearly to the project team.

7.2 TfNSW and contractor collaboration

Collaboration between TfNSW and the contractor must be at regular intervals, appropriate to the project such that project objectives and expectations between the parties remain aligned.

Formal collaboration to facilitate design federation, reviews and approvals by TfNSW must be scheduled at appropriate milestones, to ensure design deliverables are achieved as required by TfNSW and within any constraints of the project including those discovered by the contractor during the design process.

7.3 Contractor team collaboration

Similarly, the contractor team, including subcontractors are recommended to engage in appropriate collaboration to:

- achieve project objectives
- identify design constraints early
- complete deliverables as specified by TfNSW
- share information and ideas
- identify conflict and clashes.

The timing, tools and objectives of collaboration are to be defined such that collaboration is undertaken at appropriate intervals to align with the project schedule and delivery milestones and to facilitate the completion of clear objectives/outcomes for each project phase.

8 Common Data Environment (CDE) concepts

8.1 Overview

In a project delivery context, the CDE is the single source of information for any given project and is used to collect, manage and disseminate all relevant approved project documents for multi-disciplinary teams in a managed process (PAS 1192-2:2013).

A CDE is a collective name given to the group of integrated IT systems within an organisation that enables users to store, collaborate and exchange information and data.

Due to the DE framework's open data approach, the internal structure of TfNSW (that is, different agencies and divisions) and the project contracting strategies, the concept of the CDE for TfNSW projects is divided into two parts (see Figure 24):

- The contractor-CDE, owned and used by the contractor (and possibly multiple sub-contractors) for development of deliverables during the life of the project
- The TfNSW-CDE, owned by TfNSW and used by the contractor for submission of final deliverables during the life of the project. Noting TfNSW also use the TfNSW-CDE for development of TfNSW project documents, however, this is not visible to the contractor.

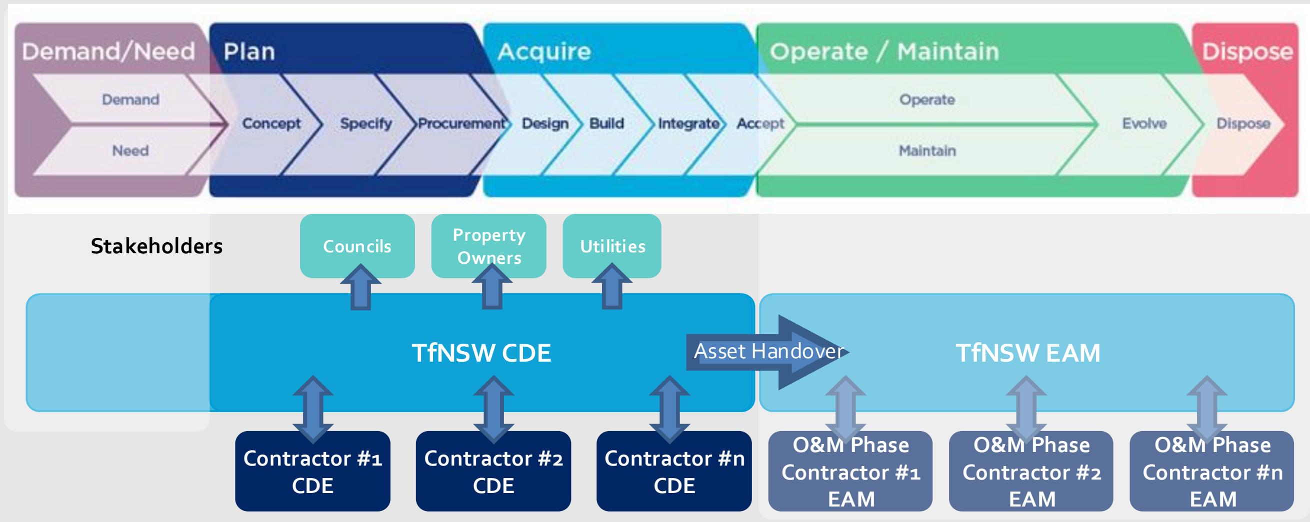


Figure 24 – Vision for contractor–TfNSW Common Data Environment interfaces

Although there is a vision to create one whole-of-Transport CDE, the current TfNSW-CDE comprises various disparate IT systems, dependent on the agency managing the delivery of the specific project. Contractors must confirm within the contract or with the designated project TfNSW DE Manager the structure of the TfNSW-CDE and the most appropriate way to interface with the system(s), automated or manual, given the specific project constraints.

For the DE outcomes to be achieved, all IT systems comprising the contractor-CDE and TfNSW-CDE for a given project need to be configured to output information and data deliverables in the formats and structure specified by this Standard. This allows TfNSW to federate project information across multiple contracts/projects/programs into a master network model.

8.2 Approval states and suitability

To govern and control the flow of information (files) between the contractor-CDE and TfNSW-CDE, the project is to utilise approval states and suitability. The adoption of these concepts will assist project team members in identifying the purpose of a file within either CDE. The requirements for tagging files with the specified attributes are controlled as Enterprise Content Management (ECM) metadata (see DMS-ST-207 – *Digital Engineering Standard, Part 2: Requirements*).

As information is produced, coordinated and validated within the contractor-CDE and submitted to the TfNSW-CDE, it must flow through a sequence of defined approval states, based on the principles of BS 1192:2007, PAS 1192.2:2013 and ISO 19650.1:2018 (see Figure 25).

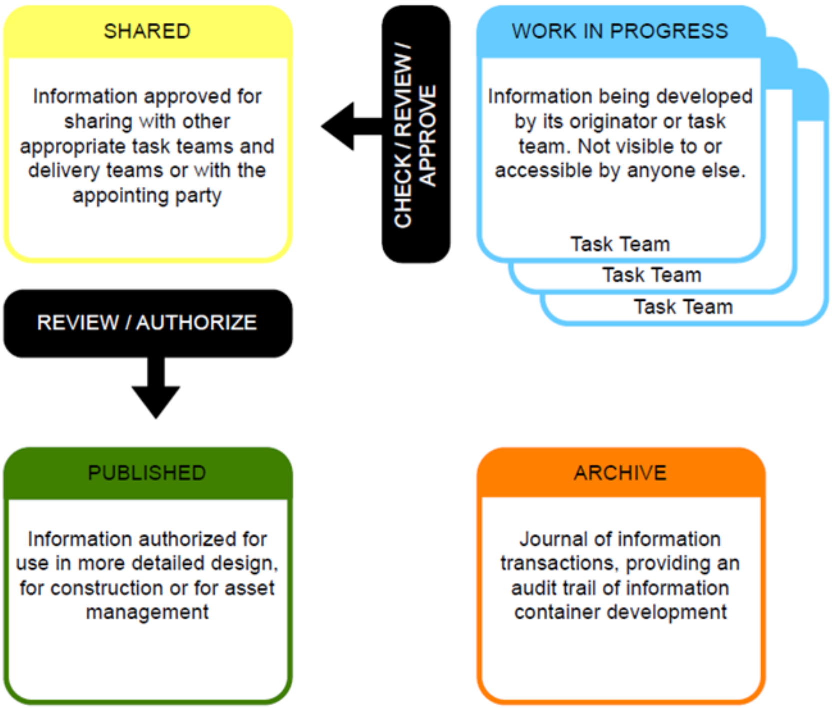


Figure 25 – Process and workflows in the CDE (ISO 19650.1)

Refer to DMS-ST-207 – *Digital Engineering Standard, Part 2: Requirements* for DE project requirements regarding the CDE and document management within the CDE.

9 Document history

Version	Published date	Summary of changes
1.0	September 2018	Interim Approach Issue
1.1		Minor updates
2.0	April 2019	Project Data Building Blocks, minor updates Separation of Part 1 and Part 2
3.0	October 2019	Clarification on usage of 'packages' of work, visualisation added, survey updated, other minor updates
4.0	April 2021	Update for road assets and multimodal Configuration Management Framework
4.1	December 2022	Update with Digital Twin, Configuration Management Framework

Appendix A DE Framework documents

Table 9 – DE Framework project delivery documents

DE discipline	Document no.	Title	Availability
All	DMS-ST-208	Digital Engineering Framework	Public
All	DMS-ST-202	Digital Engineering Standard – Part 1, Concepts and principles	Public
All	DMS-ST-207	Digital Engineering Standard – Part 2, Requirements	Public
All	DMS-SD-123	Terms and definitions	Public
Information Management	DMS-FT-533	Enterprise Content Management (ECM) Schema and Specification	Public
Systems Engineering	DMS-FT-563	Requirements Schema and Specification	Public
Survey	DMS-FT-493	Utility Schema and Specification	Public
CAD	DMS-FT-562	CAD Schema and Specification	Public
BIM Models	DMS-FT-516	BIM Schema and Specification	Public
Time	DMS-FT-520	Scheduling Schema	Public
GIS	DMS-FT-580	GIS Schema	Public

Table 10 – DE Framework delivery tools and templates

DE discipline	Document no.	Title	Availability
DE Management	DMS-FT-548	Project Data Building Blocks (PDBB) Template	DE Projects
DE Management	DMS-FT-532	Digital Engineering Execution Plan (DEXP) Template	Public
DE Management	DMS-FT-443	DE Responsibility Matrix	Public
DE Management	DMS-FT-374	DE Code Request Form	DE Projects
Information Management	DMS-FT-555	Master Information Delivery Plan (MIDP) Template	Public
CAD	DMS-FT-549	Digital Engineering CAD Title Block Standard Format	Public
BIM Models	DMS-FT-454	Model Property Check Template	Public
BIM Models	DMS-FT-534	Model Production and Delivery Table (MPDT) Template	Public
BIM Models	DMS-FT-556	Model Validation Certificate	Public
Asset Data	DMS-FT-537	DE Asset Register Template	Public
GIS	DMS-FT-581	GIS Management Plan Template	Public

DE discipline	Document no.	Title	Availability
Survey	IP-0043-GD01	Survey Schema and Specification	Public
GIS	IP-0048-TL01	Template file structure for Aboriginal Heritage Assessments GIS	Public
GIS	IP-0048-TL02	Template file structure for Biodiversity Assessments GIS	Public
GIS	IP-0048-TL03	Template file structure for GIS	Public
GIS	IP-0048-TL04	GIS validation certificate	Public

Table 11 – DE Framework technical guidance

DE discipline	Document no.	Title	Availability
All	DMS-SD-092	Guide to procuring non-standard hardware	TfNSW only
DE Management	DMS-SD-124	Application of Uniclass for Transport for NSW	Public
DE Management	DMS-SD-145	Project Data Building Blocks Guide	DE Projects
DE Management	DMS-SD-143	Project Data Schemas Guide	DE Projects
DE Management	DMS-SD-149	Using the DEXP	Public
DE Management	DMS-SD-140	Project Deliverables Requirements Guide	Public
DE Management	DMS-SD-125	Establishing the Contractor Common Data Environment	Public
Information Management	DMS-SD-128	Procurement of InEight Document Suite	TfNSW only
Information Management	DMS-SD-126	Using the new TfNSW InEight Document Suite	DE Projects
Information Management	DMS-SD-144	The Master Information Delivery Plan (MIDP) Guide	Public
Survey	DMS-SD-142	Digital Survey Requirements Guide	DE Projects
CAD	DMS-SD-139	The Digital Engineering CAD Concession	Public
BIM Models	DMS-SD-136	Setting up for BIM	Public
BIM Models	DMS-SD-137	DE Design Review	DE Projects
BIM Models	DMS-SD-129	Procurement of a Model Review Tool	TfNSW only
Visualisation	DMS-SD-130	Visualisation Requirements Guide	DE Projects
Asset Data	DMS-SD-141	Master Classification Library	Public

DE discipline	Document no.	Title	Availability
Asset Data	DMS-SD-138	Why not COBie	Public
GIS	IP-0048-SP01	Aboriginal Heritage Assessments GIS Specification	Public
GIS	IP-0048-SP02	Biodiversity Assessments GIS Specification	Public

Appendix B Terms and definitions

Refer to DMS-SD-123 – *Digital Engineering Terms and definitions* guide.

To be read in conjunction with DMS-ST-202 – *DE Standard, Part 1: Concepts and Principles* and DMS-ST-207 – *DE Standard, Part 2: Requirements.*