AS 7739.1:2023

Australian STANDARD®

Digital engineering for fixed rail infrastructure
Part 1: Concepts and principles

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RAIL INDUSTRY SAFETY AND STANDARDS BOARD

Infrastructure Standard



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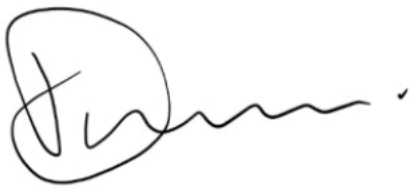
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The Standard was approved by the Development Group and the Infrastructure Standing Committee in November 2022. On 30 January 2023 the RISSB Board approved the Standard for release.

This standard was issued for public consultation and was independently validated before being approved. Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard.

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this Standard. Their efforts ranged from membership of the Development Group through to individuals providing comments on a draft of the Standard during the open review.

I commend this Standard to the Australasian rail industry as it represents industry good practice and has been developed through a rigorous process.



Damien White
Chief Executive Officer
Rail Industry Safety and Standards Board

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This Standard was prepared by the Rail Industry Safety and Standards Board (RISSB) Development Group AS 7739 Digital engineering for rail – Part 1: Concepts and principles. Membership of this Development Group consisted of representatives from the organizations listed on the inside cover of this document.

Objective

The objective of this Standard is to:

- build on current developments and progress with digital engineering (DE);
- combine globally leading practice;
- define contemporary best practice;
- specify building blocks for national consistency;
- reduce complexity for both asset owners and rail industry suppliers;
- provide a method for creating and classifying information relating to rail assets in a consistent manner; and
- simplify the mapping of asset information by providing a consistent and repeatable information delivery method.

This Standard is Part 1 of the AS 7739 Digital engineering for fixed rail infrastructure series.

- Part 1: Concepts and Principles

  AS 7739 Part 1 provides DE guidance that introduces and defines key concepts and principles for the ANZ rail industry. This guide provides detailed information on how to build data management capability and the overarching digital framework required for successful DE project implementation.

  It is not intended to be directly referenced in project procurement contracts, as it does not provide the appropriate level of detail necessary to adequately specify DE project deliverables.

- Part 2: Technical Requirements

  AS 7739 Part 2 provides detailed technical requirements (including specifications and procedures) for the procurement and management of DE project deliverables.

Compliance

There are four types of provisions contained within Australian Standards developed by RISSB:

1. Requirements.
2. Recommendations.
3. Permissions.
4. Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term ‘shall’.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term ‘should’.

Recommendations recognize that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied or other controls are more appropriate or better.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term ‘may’.

Constraints - provided by an external source such as legislation. Constraints are identified within the text by the term ‘must’.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities, or interfacing organizations where the risk may be shared.

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1 Scope and general

1.1 Introduction

1.1.1 Preface

Digital engineering (DE) is a term that is used globally and has been adopted by both asset owners and delivery partners alike. Given it is a relatively new term used to describe business processes that are relatively advanced yet also conceptual, there currently exists a wide range of interpretations and expectations about DE.

Like all technological change, DE will continue to grow and evolve rapidly as more organizations adopt digital processes and develop new innovations with DE. This Standard aims to provide guidance and instruction on best-practice DE, based on leading global initiatives.

Given the current diversity in thinking around DE, it is important to clarify a few key points regarding this Standard:

(a) DE is an entirely new way of working that represents a convergence of master data management, business process optimization and emerging technologies,

(b) DE represents a completely new approach to data management in the rail sector,

(c) DE should not be considered as an incremental change, or basic optimization to existing ways of working, and

(d) DE should not be used interchangeably to describe BIM and general information management.

This Standard aims to increase general awareness and technical understanding of DE, however the target audience is intentionally asset owner organizations due to their central role in the overall rail industry (see figure 1.1).



Figure 1.1: Asset owners and the supply chain

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1.1.2 General

AS 7739 (all parts) provides information on best-practice DE based on International Standards and leading digital initiatives from global organizations and Australian and New Zealand (ANZ) transport agencies.

This series aims to inform the ANZ rail industry by providing guidance, requirements, and recommendations for the use of DE in planning, design, and construction of rail infrastructure projects.

The AS 7739 series consists of two parts:

(a) Part 1: Concepts and principles (this Standard);

(b) Part 2: Technical requirements.

The advice provided in this series builds on cross-sector digital innovation, established business processes, major infrastructure projects, and leading global sources. The resulting guidance defines how to enable DE standardization throughout the ANZ rail industry.

See Figure 1.2 for detail on how AS 7739 (all parts) aims to provide nationally consistent:

(c) high-level advice for organizational strategies and planning;

(d) more informed guidance and managerial processes;

(e) detailed technical solutions and data specifications.

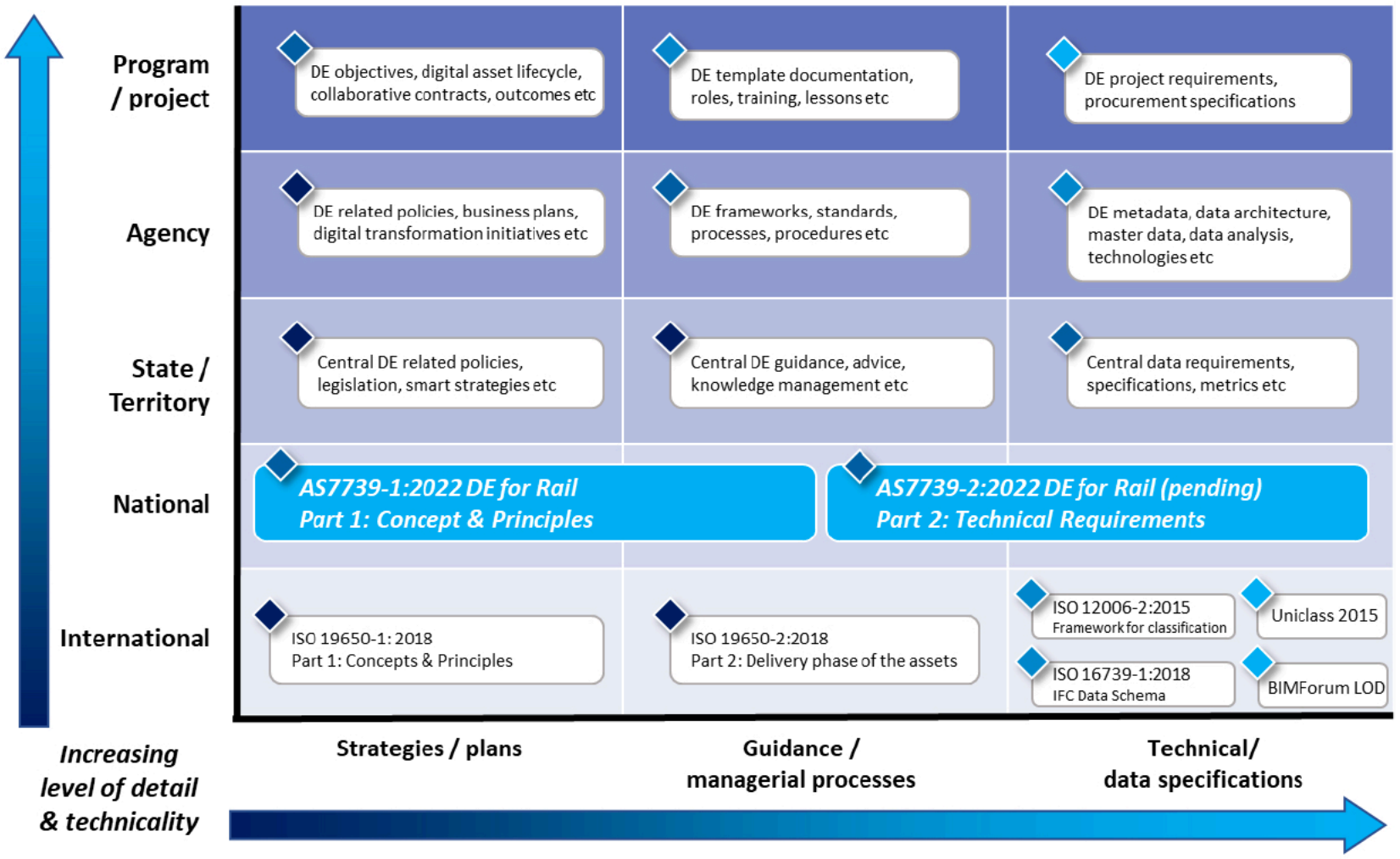


Figure 1.2: Landscape of DE standardization – from international guidance through to detailed project specifications

Further detail and specification could be required at a state/territory, agency, and program level, to ensure suitable requirements are established for the procurement and exchange of DE project deliverables.

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1.1.3 International Standards

1.1.3.1 Overview

ISO 19650 is a suite of International Standards (published from 2018 onwards) that provides guidance on the use of BIM to improve information management over the lifecycle of buildings and civil works. These standards elevated many of the concepts taken from the previous UK BS/PAS 1192 suite of standards (released between 2007-2018), to cater for a broader, more generic international audience.

In the context of the ANZ rail industry, there has been a rapid uptake in the use of these standards, and they are now commonly regarded as global best practice for project management. Client agencies at all levels of government are now commonly prescribing guidance and project deliverables in accordance with ISO 19650. It is worth noting that references to ISO 19650 were even included in the Infrastructure Australia 2021 Australian Infrastructure Plan (released Sept 2021), demonstrating the high regard in which these standards are held.

See Appendix B for an overview of the key concepts and processes defined in ISO 19650.

1.1.3.2 Digital maturity of ISO 19650

ISO 19650 Part 1 provides a three-stage maturity model, that denotes progress from analogue and digital information management. Stage 2 maturity, which represents a blend of manual and automated information management processes, is considered BIM according to the ISO 19650 series.

ISO 19650 does not provide any further details on:

(a) a roadmap or expected timeline to progress to Stage 3 maturity; or

(b) possible solutions to improve digital maturity beyond Stage 2.

See Appendix C for current limitations of ISO 19650 Stage 2 digital maturity.

See Table 1.1 for a summary of the digital maturity model.

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Digital Maturity	Stage 1	Stage 2	Stage 3
Information layer	Unstructured data	Unstructured data	Unstructured BIG data
	---------- Structured data ----------		
	-	Federated information models	Federated information models
	-	-	Object-based server information models
Technology layer	File/ Model/ Container	File/ Model/ Container	Database/ Query/ Model/ Container
	---------- Information management technology based ----------		
	---------- common data environment (CDE) ----------		
Standards layer	National Standards	ISO 19650 with Regional/ National Annexes	Process standards to be developed

Table 1.1: ISO 19650 digital maturity model

Stage 3 presents a significant improvement from the current maturity level of ISO 19650, and offers a range of new digital capabilities, such as:

(a) the introduction of big data;

(b) the introduction of object-based server information models, that provide further capability than current federated information models;

(c) a shift from information containers (otherwise known as file-based data management), to the use of databases and support for database queries;

(d) new digital standards that will enable further levels of process automation.

Collectively these new digital capabilities will enable a step change in productivity, through improved data management methodologies, that will transform the way project and asset information is managed over the complete lifecycle.

In the context of the ANZ rail industry, pioneering work is currently underway to build more advanced ways of working that closely align with Stage 3 digital maturity. Leading ANZ transport organizations have commenced programs of innovation, and are already developing new digital processes and frameworks, trialing emerging technologies and building more advanced data management capabilities. In short, the ANZ rail industry is progressing rapidly, with digital standardization that extends well beyond the current stage 2 maturity of the ISO 19650 series.

The AS 7739 series builds on the foundations established in ISO 19650 and introduces more advanced data management concepts and principles that collectively define best practice DE for rail infrastructure.

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1.1.4 Standardization of the ANZ rail industry

1.1.4.1 Background

DE offers a range of transformational benefits across the full asset lifecycle of rail infrastructure projects, using digital technologies and optimized ways of working. DE techniques are now commonly applied on major rail infrastructure projects, realizing immediate benefits such as improved design coordination, faster project delivery and less project variations.

That said, many of the benefits of DE have often been short-lived, hindered by inconsistent methodologies, a lack of interoperable data and generally low digital maturity. Furthermore, there has been little consideration for aligned digital processes over the full asset lifecycle, resulting in limited reliability or re-use of project information beyond single phases of the lifecycle.

Most importantly, there has been no agreed DE standards or guidance that define best practice across the ANZ rail industry. Rail agencies and asset owners have individually developed bespoke DE project requirements, with varying levels of detail and specification. This has made it challenging for the rail industry to interpret and respond to a growing number of diverse DE terms, definitions, conventions, requirements and specifications.

It is now universally recognized by both the public and private sectors that an ad-hoc and siloed approach is not sustainable. There is a need for consistency, developed in partnership by the ANZ rail industry, to define and agree on a common approach to DE for rail infrastructure projects. Standardization will enable digital transformation and unlock a step-change in productivity throughout the rail infrastructure sector.

1.1.4.2 Current landscape

The ANZ rail industry is diverse, comprising numerous government bodies, asset owners and industry suppliers – all with varying levels of digital capability. Efforts to harmonize the uptake and implementation of DE across the ANZ rail industry should therefore recognize and be developed in the context of the current environment.

ISO 19650 provides a well-recognized foundation for national standardization. It is noted however that ISO 19650 is a global standard, and as such, it intentionally lacks technical detail and requires further levels of technical specification by clients prior to adoption or direct implementation of the Standard.

In the context of the ANZ rail industry, there are numerous DE related initiatives currently inflight at a jurisdictional government or agency level. These initiatives are working at varying levels of detail, from high-level strategic programs, to detailed data specifications and related technologies.

Furthermore, each state and territory has their own legislation, contract models, project requirements and ways of working that could also influence DE strategies or detailed specifications.

1.1.4.3 The need for harmonization

The development of DE at a jurisdictional, agency and project level is accelerating throughout the ANZ rail industry. Key factors driving this change include the increasing industry capability, the rapid uptake of new technologies and the growing demand for data-driven insights on major rail infrastructure projects.

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This trend of organic growth is likely to continue and if left unchecked, could result in a diverse landscape of localized and incompatible DE solutions that would require significant expense to harmonize at a later stage. It is for this reason rail industry commentators have often drawn comparisons with the operational challenges caused by numerous rail gauges throughout Australia.

There is now a clear need for national harmonization of DE initiatives across the ANZ rail industry.

National DE standardization provides the following benefits:

(a) Nationally consistent terms, definitions and conventions, thereby removing current ambiguities that restrict collaboration within the ANZ rail industry.

(b) Enables data sharing between rail projects, program, agencies and jurisdictions.

(c) Enables benchmarking and master data management across the ANZ rail industry.

(d) Reduces complexity for rail industry providers providing digital services to multiple ANZ rail infrastructure managers.

(e) Builds digital capabilities and attracts new talent into the rail industry.

1.1.4.4 Role of AS 7739

The development of DE standards for the rail infrastructure sector is not starting from scratch. There are already pockets of excellence across ANZ and globally that can be adapted to help accelerate the development of national standards. The AS 7739 series has been developed in collaboration with DE subject matter experts from the private and public sectors as well as academia. The resulting documentation builds on global standards, captures best practice from leading ANZ rail industry initiatives and is informed by recent project case studies.

AS 7739 (all parts) covers fixed infrastructure associated with the railway network, which includes overarching principles, data management processes and technical requirements, to define good practice DE for project information deliverables.

1.2 Scope

This Standard provides a common baseline to establish a standardized approach for improved procurement, management, and exchange of project information deliverables through DE. This is aimed at improving digital collaboration between asset owners and their supply chains and promotes further digital transformation of the ANZ rail industry.

1.3 Exclusions

DE applications and technologies that are outside the scope of this Standard include:

(a) MODEL-BASED SYSTEMS ENGINEERING;

(b) blockchain;

(c) advanced building materials;

(d) pre-fabrication and modular construction;

(e) 3D printing and additive manufacturing;

(f) autonomous construction;

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(g) augmented reality;

(h) big data and predictive analysis;

(i) internet of things, remote sensors, fog/cloud computing and smart infrastructure;

(j) real time collaboration.

Rail specific elements that involve detailed circuits and safety critical systems are currently outside the scope of this Standard. This includes techniques for modelling and management of rail systems relating to the following engineering disciplines:

(k) Signalling.

(a) Communications.

(b) High voltage / low voltage power.

(c) Overhead wiring.

(d) Earthing and bonding.

The operations and maintenance (O&M) phase of the asset lifecycle is intentionally excluded in this release due to significant technical complexities associated with transforming current practices and commercial challenges with varying long-term contracts with existing enterprise asset management systems.

Fleet/rolling stock is excluded due to comparative differences between civil construction and manufacturing of rolling stock.

1.4 Structure of this Standard

The AS 7739 series comprises several key topics as follows:

(a) DE key concepts – General background, concepts and advice on DE and data management.

(b) DE business setup – Business improvements required prior to procurement and implementation of DE on rail infrastructure projects.

(c) DE project planning – Activities required for DE scoping and specification in project contracts, to inform procurement of DE services.

(d) DE project delivery – Activities required for successful delivery of DE services for rail infrastructure projects.

This Standard covers three specific subjects for each of the key topics, (see Table 1.2). The table also identifies the primary audience (or action owner) for each of the subjects, which include either the asset owner, the delivery partner or all stakeholders.

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Key topic	Subject	Primary audience	Standard section
DE key concepts	1. Data management	All	2
	2. Metadata to support DE	All	3
	3. Data models to support DE	All	4
DE business setup	4. Common Data Model	Asset owner	5
	5. Introduction to Reference Data Entities	Asset owner	
	6. Introduction to Master/Operational Data Entities	Asset owner	
DE project planning	7. Project scope	Asset owner	6
	8. Information Deliverable Scope	Asset owner	
	9. Project data models	Asset owner	
DE project delivery	10. Project procurement	All	7
	11. Digital project deliverables	Delivery partner	
	12. Structured datasets	All	

Table 1.2: Structure of AS 7739 Part 1

AS 7739 Part 1 provides the following level of detail with the subjects listed in Table 1.2:

(e) Subject items 1 to 3: Concepts explained in detail.

(f) Subject items 4 to 12: Concepts and processes introduced, with technical details explained in AS 7739 Part 2.

It is important to note that the primary audience for most of these subjects is the asset owner, given their central role in the specification, procurement, and long-term management of DE deliverables. See Figure 1.3 for a visual summary of the document structure.

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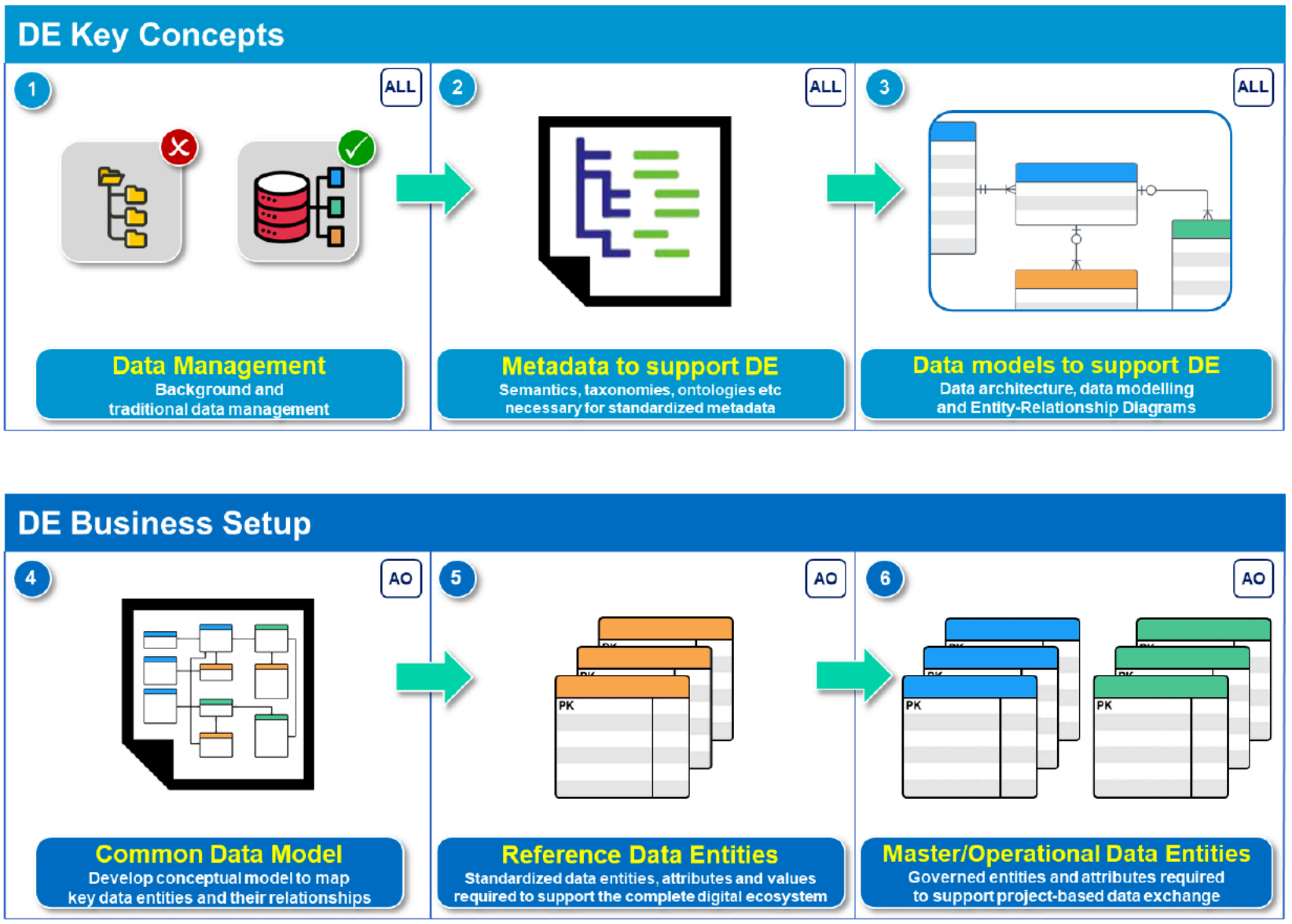


Figure 1.3: Business process required to establish DE

See Table 1.3 for a further breakdown of this Standard's content.

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	Subject	Details
1	**Background on Data Management**	**Primary Audience:** All stakeholders **Role(s):** All roles **Standard Section:** 2 **Summary:** Background and traditional data management. **Details:** Background and traditional data management, thinking beyond BIM, What is DE? How does DE work? Principles and benefits
2	**Metadata to Support DE**	**Primary Audience:** All stakeholders **Role(s):** All roles **Standard Section:** 3 **Summary:** Semantics, taxonomies, ontologies etc necessary for standardized metadata. **Details:** Semantics (taxonomies and ontologies), asset classification, ISO 12006.2 and Uniclass
3	**Data models to support DE**	**Primary Audience:** All stakeholders **Role(s):** All roles **Standard Section:** 4 **Summary:** Data architecture, data modelling and entity-relationship diagrams (ERD). **Details:** Data modelling concepts, terminologies and notations, Entity-Relationship Modelling, Conceptual / logical / physical models
4	**Common Data Model**	**Primary Audience:** Asset owner **Role(s):** DE developer(s) **Standard Section:** 5 **Summary:** Develop conceptual model to map key data entities and their relationships.

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Details:

Build a comprehensive ERD using a standardized form of data modelling notation (e.g. crow's foot) to identify and map key data groups, entities, identifiers, attributes, and relationships.

Data entities may be categorized by the following types:

- Reference data – Data libraries relevant to all projects
- Master data – Relevant to all datasets on a single project
- Operational data – Relevant to specific datasets

5	**Reference Data Entities**	**Primary Audience:**	Asset owner
		Role:	DE developer(s)
		Standard Section:	5
		Summary:	Standardized data entities, attributes and values required to support the complete digital ecosystem.
		Details:	Compile libraries of master data (including both primary keys and associated attributes) to provide consistent entities for project/asset data. All master data shall be machine readable, to enable automated data exchange and re-use for all parties throughout the digital ecosystem, over the complete asset lifecycle.
6	**Master/ Operational Data Entities**	**Primary Audience:**	Asset owner
		Role:	DE developer(s)
		Standard Section:	5
		Summary:	Governed entities and attributes required to support project-based data exchange.
		Details:	Develop consistent database entities specific to each type of project dataset. Entities comprise both master and operational data fields, based on the specific requirements for each type of dataset.
7	**Project Scope**	**Primary Audience:**	Asset owner
		Role:	Project team
		Standard Section:	6
		Summary:	Define project scope, based on operational plans, systems engineering methodologies (including business and system requirements) and business case approval processes.

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		Details: Define project scope, based on operational plans, systems engineering methodologies (including business and system requirements) and business case approval processes.
8	**Information Deliverable Scope**	**Primary Audience:** Asset owner **Role:** Project team & DE manager(s) **Standard Section:** 7 **Summary:** Scope-up information deliverables required to plan, design, build and operate new infrastructure. **Details:** Scope-up information deliverables (i.e. project datasets), that are necessary to plan, design and build physical infrastructure. This exercise should consider opportunities for data sharing, re-use and federation, to maximize benefits and opportunities with key project datasets.
9	**Project Data Models**	**Primary Audience:** Asset owner **Role:** DE manager(s) **Standard Section:** 8 **Summary:** Individual data models, codifying the project scope, established for each specific project or contract **Details:** Develop bespoke data models, that are created specifically per project dataset, per project contract. These essentially pre-populate the data common data model with known metadata, specific to each project, to form the project data models. These are typically developed by the project client prior to commencing procurement, and form part of the tender documentation for the tenderers to assess and respond.
10	**Project Procurement**	**Primary Audience:** Asset owner **Role:** Project team & DE manager(s) **Standard Section:** 9 **Summary:** Engage delivery partner responsible for delivering scope including project datasets **Details:** Upon completion of the procurement process, further work could be required to update and / or revise the project data schemas with the winning tenderer. Once final changes are formally agreed, the project data schemas for each form of dataset is essentially locked in place, to ensure all metadata is controlled going forward.

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11	**Digital Project Deliverables**	**Primary Audience:** Delivery partner **Role:** Digital engineer(s) **Standard Section:** 9 **Summary:** Database templates, embedded into project authoring & management tools, to codify all deliverables **Details:** The project partner (e.g. designer, builder etc) is to install the agreed project data model into their project authoring & data management tools. The project teams are then to tag all subsequent project deliverables with the project data model, to ensure correct metadata is applied to all respective project datasets.
12	**Structured Datasets**	**Primary Audience:** Asset owner & delivery partner **Role:** DE manager & digital engineer(s) **Standard Section:** 9 **Summary:** Codified project deliverables, federated in a digital ecosystem of linked databases, i.e. the connected digital ecosystem (CDE 2.0) **Details:** The delivery partner submits all project deliverables as structured datasets, that are able to be federated within the project CDE 2.0. Structured data is now available as a key resource for all permitted stakeholders, enabling data-driven decisions and insights by all relevant parties.

Table 1.3: Contents of AS 7739 Part 1

1.5 Normative references

There are no normative references in this document.

NOTE: Documents for informative purposes are listed in the Bibliography.

1.6 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

1.6.1
asset
item or object that has potential or actual value to an organization

1.6.2
attribute
characteristics or properties of an entity

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1.6.3
building information modelling
BIM
process of designing, constructing and maintaining a built asset using object-based 3D modelling

1.6.4
classification
see taxonomy

1.6.5
computer aided design
CAD
digital 2D or 3D drawings that replicate manual drafting techniques. This often involves using disconnected drawings that are manually drafted using lines, arcs and circles, which are then overlaid and coordinated in two dimensions

1.6.6
common data environment
CDE
agreed source of information for any given project or asset, for collecting, managing and disseminating each information container through a managed process

1.6.7
common data model
a standardized data model, based on a top-down ontology, developed for the rail-sector to exchange data in a connected digital ecosystem

1.6.8
connected digital ecosystem
CDE 2.0
digital ecosystem of linked databases, that manages and exchanges datasets & metadata, using consistently structured data architecture, to ensure semantic interoperability over the asset lifecycle

1.6.9
constraint
restriction placed on data, usually expressed in the form of business rules

1.6.10
data architecture
a broad term used to describe the design of data models and associated artefacts that connect an enterprise strategy with its data management framework

1.6.11
data model
a model of the users' data requirements, usually expressed in terms of the entity-relationship model

1.6.12
data modelling
process of creating a specific data model for a determined problem domain

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1.6.13
data schema
logical blueprint of how a database is constructed e.g. tables, relationships, indexes, views

1.6.14
database management system
DBMS
computer software program used to manage and query a database

1.6.15
database query
request to access or manipulate data from a database table or combination of tables, typically performed using Structured Query Language (SQL)

1.6.16
dataset
container or collection of data, that can be manipulated as a single unit

1.6.17
digital engineering
DE
a collaborative way of working, using semantic data management, to enable more productive methods of project delivery and asset management

1.6.18
entity
independent unit of the built environment with a characteristic form and spatial structure, intended to serve at least one function or user activity

1.6.19
entity-relationship diagram
ERD
graphical diagram that represents an underlying entity-relationship data model

1.6.20
foreign key
attribute that references a primary key from another entity, thereby linking two entities

1.6.21
geographic information system
GIS
spatial system that creates, manages, analyzes and maps all types of data

1.6.22
Industry Foundation Classes
IFC
specification for open BIM to support an open standard for information exchange, that is developed and maintained by Building SMART International

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1.6.23
information container

named persistent set of information retrievable from within a file, system, or application storage

1.6.24
information management

tasks and procedures applied to in-putting, processing and generation activities to ensure accuracy and integrity of information

1.6.25
information model

term associated with BIM, generally used to describe a defined collection of data including documentation, geometrical (graphical) and non-geometrical (non-graphical) data. Information Models are linked together using a common data structure (schemas) and classification system

1.6.26
master data

metadata for that provides details and context for business activity. It uses uniform structure and entities to drive business processes, enable analytics and establish the golden thread of data (i.e. the digital asset lifecycle)

1.6.27
metadata

data about data that enables datasets to be structured, managed and federated

1.6.28
not only structured query language
NoSQL

type of non-relational database that is distributed to enable large-scale data access

1.6.29
object

any real-world thing that can have data stored about it

1.6.30
ontology

process of defining relationships between objects, systems and concepts

1.6.31
operational data

metadata created when undertaking business activities, processes and transactions

1.6.32
primary key

attribute that uniquely identifies an instance of the entity

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1.6.33
project data model
PDM

a bespoke data model, based on the common data model template, developed prior to commencing procurement, to support project data exchange in a connected digital ecosystem

1.6.34
reference data

metadata that provides standardized classification, categorization or organization of other data

1.6.35
relationship

dependency or association between two entities

1.6.36
semantics

systematic organization of data using consistent conventions, to reliably transfer information (e.g. context, meaning and relationships) about objects between parties

1.6.37
semantic data management

range of techniques that can be employed for storing, querying, manipulating, and integrating data based on its meaning

1.6.38
semantic interoperability

ability for computer systems to unambiguously exchange and federate data with universal meaning

1.6.39
structured query language
SQL

dominant, standardised database language, used to define, control, manipulate and access relational data, stored in a DBMS

1.6.40
taxonomy

systematic arrangement of objects into meaningful groups by class, using type-of relationships i.e. classification

General rail industry terms and definitions are maintained in the RISSB Glossary: https://www.rissb.com.au/products/glossary/

1.7 Abbreviations

(a) ANZ
Australia and New Zealand

(b) DEXP

digital engineering execution plan

(c) ICT

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information and communication technology

(d) SE
systems engineering

(e) WBS
work breakdown structure

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2 Digital engineering concepts

2.1 Background

2.1.1 Traditional information management

In recent years there have been numerous studies researching the performance of transport infrastructure projects and the causes of time and cost overruns that impact successful project delivery. An overarching theme identified throughout these studies was the frequent nature of overruns during project delivery, with larger projects failing more frequently and with greater relative overruns.

A common finding from this research has identified that scope change as the leading cause of project variations and budget overruns, which is commonly linked with information management on construction projects.

Issue	Detail
Document-based	Project information is created in reports, and stored in segregated systems across a range of document management platforms
Disconnected	Created within siloed business units, with little consideration for consumption of information down the chain
Manual	Heavily administrative, with little consideration for process automation or information re-use
Ad-hoc	Projects are delivered inconsistently, with variable processes applied across the range of delivery programs
Subjective	Reliant on the personal knowledge, experience and relationships of individuals
Non-repeatable	Projects are delivered as though they are “one-off prototypes” with little consideration for creation of reliable, re-useable asset information or knowledge

Table 2.1: Challenges with traditional information management in the construction sector

Poor information management is now recognized to be a leading cause of overruns on construction projects and is a frequent trigger for scope change, unforeseen errors and project delays. See Table 2.1 for some of the more common issues with information management that are observed universally in construction and infrastructure projects around the world.

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2.1.2 Traditional data management

Traditionally on rail infrastructure projects, project information deliverables are developed by numerous parties, working independently, using siloed processes with discrete project breakdown structures and unique coding for all subsequent project deliverables.

For example:

(a) WBS developed for the project schedule;

(b) cost breakdown structures (CBS) developed for the project cost estimate;

(c) design packages developed by the engineering teams;

(d) work packages created by the construction teams, etc.

Project information deliverables within each project are therefore typically discrete, with little consideration for data interoperability or re-use by other downstream parties, at later stages of the asset lifecycle.

Furthermore, there has been little regard for how data within project deliverables could be associated across multiple project disciplines or across multiple projects to enable an enterprise or portfolio view. Any attempts to build insights on or across projects based on specific attributes (e.g. asset type, system components, asset location, delivery teams etc.) has therefore been challenging and often required heavily manual processes.

Risk	Cause	Consequence
Data loss between stages	Insufficient contract specification of data deliverables	Less informed decisions, slower ramp up and recreation of deliverables required
Discovery of issues during construction	Poor visibility of interfaces between design packages and construction staging	Delays on site, disruptions to delivery, and increased variations
Stakeholder issues	Poor visibility and communication of project scope and construction impacts	Miscommunication of work on site. Stakeholder resistance and loss of reputation
Cost blow-out	Unforeseen changes due to unclear scope, design errors, insufficient coordination, unplanned works etc	Rework, scope changes, cost variations
Maintainer receives insufficient handover data	Information does not exist, is not handed over in a structured way or is unreliable	Additional cost and effort to capture asset data, manual process for asset data capture

Table 2.2: Issues with poor data management

2.1.3 The need for structured data

To address these issues, digital ways of working are now emerging in the construction sector that aims to improve project controls, enable greater cost certainty and deliver a step-change in project delivery.

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This is transforming the way project and asset information is managed through the adoption of emerging digital technologies and new business processes that create cost savings and improve productivity for both contractor and client stakeholders. By structuring project data consistently, it can be reliably re-used by all project stakeholders to make more informed, data-driven decisions throughout the project lifecycle.

The digital transformation of the construction sector has been steadily accelerating over the past 20 years, which is largely due to the UK government's commitment to BIM, announced formally in the UK Government Construction Strategy in 2011. This policy set a new direction for the rail industry, and was a catalyst for new ways of working, such as:

(a) defined information requirements over traditional project specifications;

(b) digital deliverables over paper documentation;

(c) model-based 3D design over 2D drawings;

(d) structured data over ad-hoc file structures;

(e) client leadership over supplier direction.

In the time since then, BIM is now rapidly becoming business-as-usual on major infrastructure project globally however, the uptake of BIM is still largely being led by rail industry suppliers instead of the client organizations. BIM in isolation, provides project benefits, however, for it to be truly adopted by clients, it should be integrated with many other project datasets and then transformed to become digital.

2.2 Thinking beyond BIM

2.2.1 The evolution of design

BIM is now a common term in the rail infrastructure sector however, there is still much uncertainty around a clear definition of what BIM is.

ISO 19650 defines BIM as the use of a shared digital representation of a built asset to facilitate design, construction, and operation processes to form a reliable basis for decisions. This definition is intentionally ambiguous to serve the broadest range of assets, organizations, cultures, and appointment roles.

This formal definition is relatively conceptual, as it does not establish any specific conventions, boundaries, or limitations of BIM. Users could be correct in assuming that the process of BIM involves the production of geometric or object-based 3D modelling, however, the standard does not make any clear association with these elements. The definition of BIM is effectively open to interpretation, and further clarity is needed to assist user understanding for the ANZ rail industry.

A simpler way to understand BIM is to consider how the design and delivery of buildings and infrastructure have evolved. Referring to Figure 2.1, the design process has generally evolved through the following key deliverables:

(a) 2D geometric drawings – initially manually and then electronically through the introduction of computer-aided design (CAD) to represent 2D and 3D geometries.

(b) 3D geometric models – for visualization and improved stakeholder engagement.

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(c) 3D BIM Models – 3D object-based (or smart) 3D models enriched with linked data to enable BIM-centric outputs often described by dimension, e.g. 3D, 4D, 5D, BIM.

(d) DE – enabling an ecosystem of linked databases based on consistently structured datasets and machine-readable metadata.

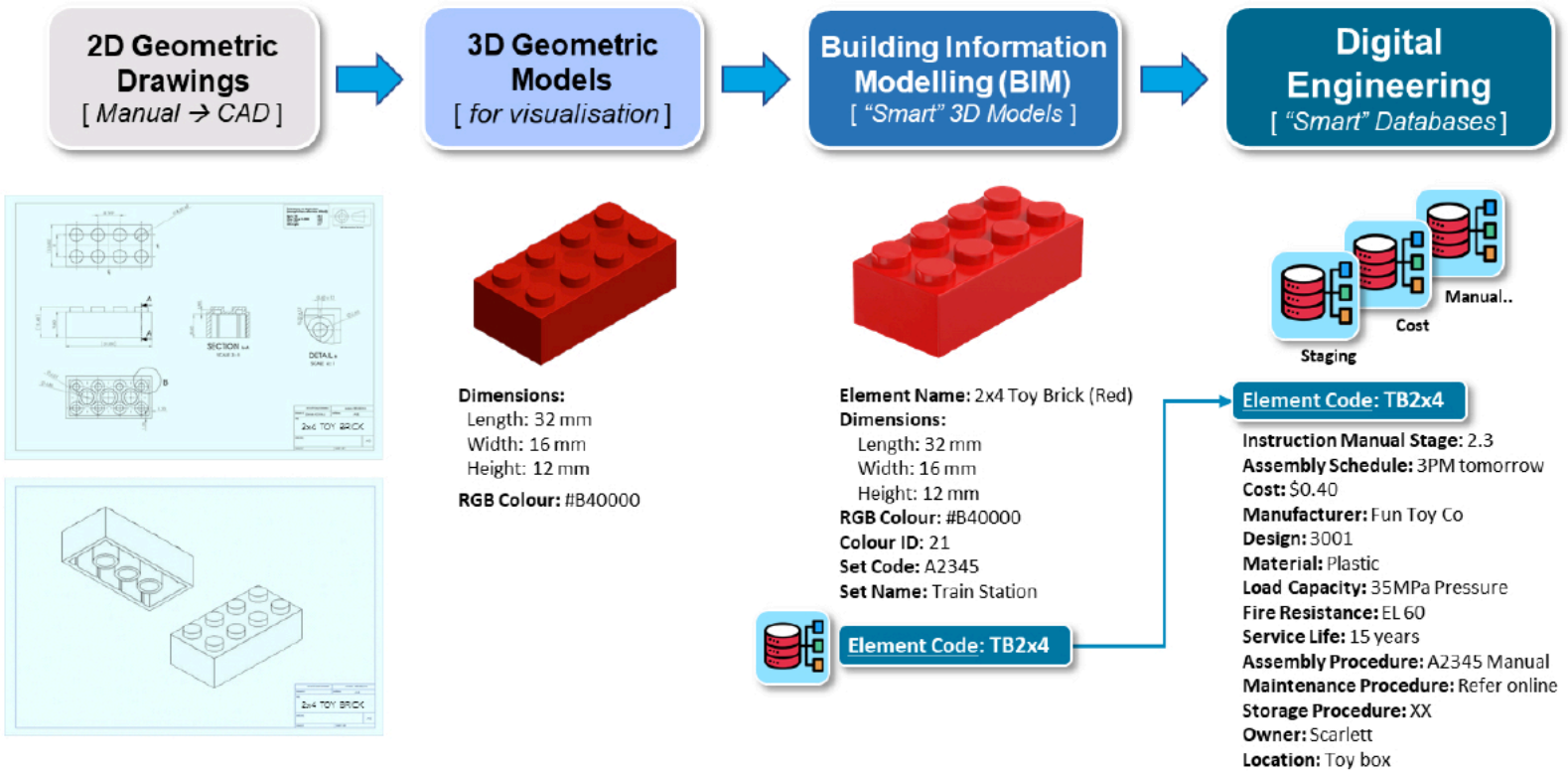


Figure 2.1: The evolution of design processes

The emergence of BIM has provided new, more visual ways of working that have significantly improved design coordination and information management. BIM-centric concepts such as 4D BIM (i.e. 3D BIM Model + project schedule) or 5D BIM (3D BIM model + cost breakdown) have been adopted by the rail industry to describe new capabilities, develop new methodologies, and achieve smarter design outcomes.

2.2.2 The evolution beyond BIM

Over the past 10 years, BIM has proven to be a significant catalyst for technological change and has unlocked substantial productivity improvements for rail industry and asset owners. Outside of the direct benefits, however, BIM in isolation has been unable to achieve broader digital transformation as many have expected. This has resulted in BIM remaining disconnected from other key datasets, lifecycle stages and business processes.

Industry experience has now shown that BIM-centric processes and terminologies have the potential to limit opportunities for broader integration outside specific use-cases. This can serve to hinder the opportunity for automated business integration, federation across a portfolio of projects or reliable re-use through the asset lifecycle.

More progressive organizations are now starting to think beyond BIM and are considering BIM models as a dataset in the context of a broader ecosystem of project datasets. This requires a new approach to data management that enables numerous datasets from many sources to be automatically associated through structured, machine-readable data.

DE is the next step in this evolution.

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2.3 What is digital engineering?

DE is defined as a collaborative way of working, using semantic data management to enable more productive methods of project delivery and asset management.

DE uses data modelling to represent all aspects of physical infrastructure and support all activities over the complete asset lifecycle. These models use consistent data architecture with semantic interoperability to ensure all datasets are machine-readable, and can be managed, exchanged, federated, and re-used in an ecosystem of linked databases. DE enables data integration across all stakeholders, creating a digital thread, supporting process automation, and allowing data to be managed more effectively as an asset.

See Figure 2.2, on how DE brings together the complete ecosystem of deliverables that are created over the course of project delivery.

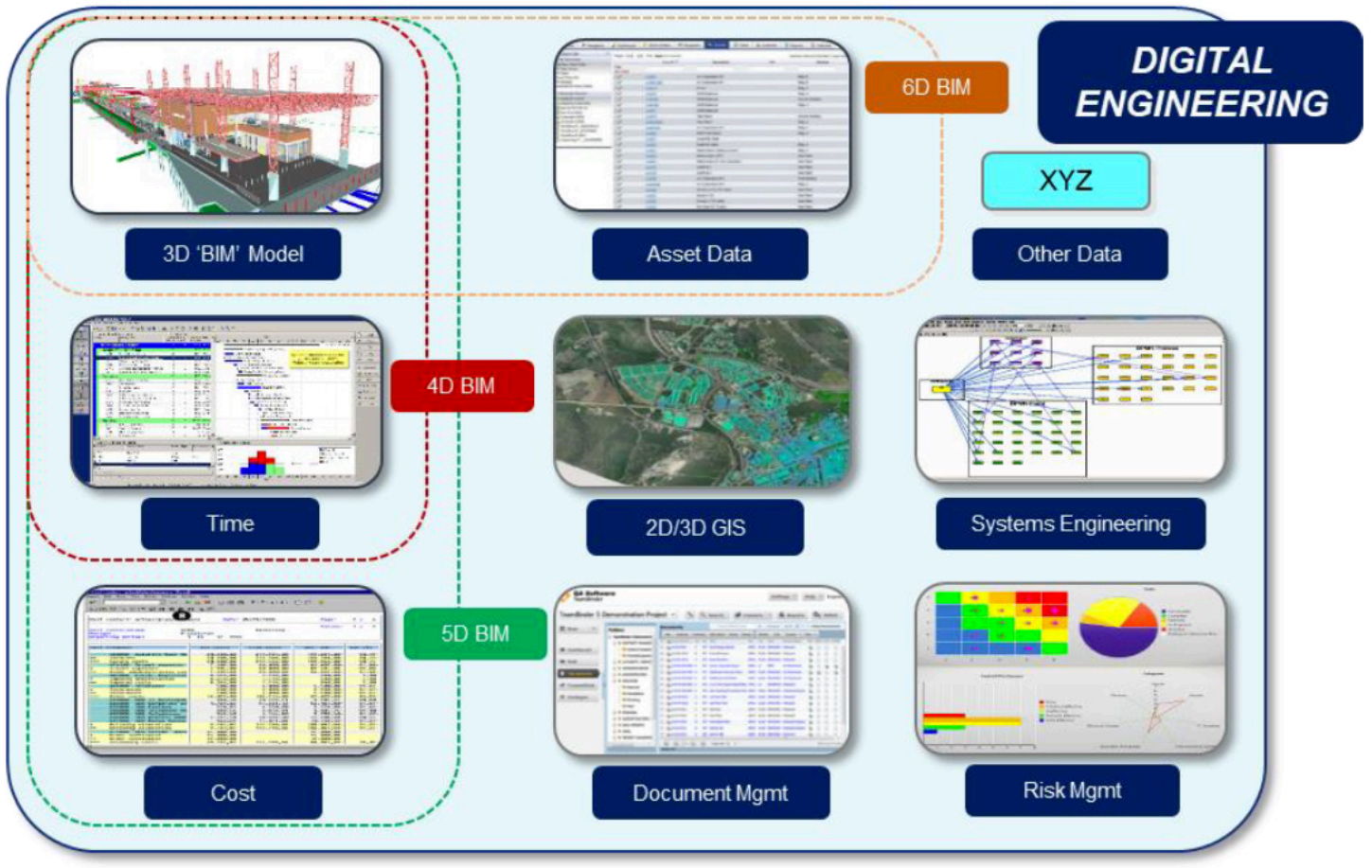


Figure 2.2: Digital Engineering – an ecosystem of digital project deliverables

Key project datasets include, but are not limited to, the following:

(a) Site surveys of above and below-ground features (inc. utilities).

(b) Geotechnical surveys.

(c) 3D point clouds (if laser scanning is undertaken on the project).

(d) Documents (e.g. design reports, construction certification, operational readiness documentation etc.).

(e) 2D CAD drawings.

(f) 3D building information models – otherwise known as BIM models.

(g) Geographic information systems (GIS) databases.

(h) Project schedules.

(i) Cost estimates.

(j) Project registers, including (but not limited to):

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i. requirements registers (for systems engineering);

ii. asset registers;

iii. risk registers;

iv. safety registers;

v. defects registers, etc.

Traditionally in the construction sector, datasets have typically remained siloed, due to a file-based approach to data management. Furthermore, the metadata associated with each type of dataset has been developed in isolation, with no consideration for interoperability or automated linkage across disciplines.

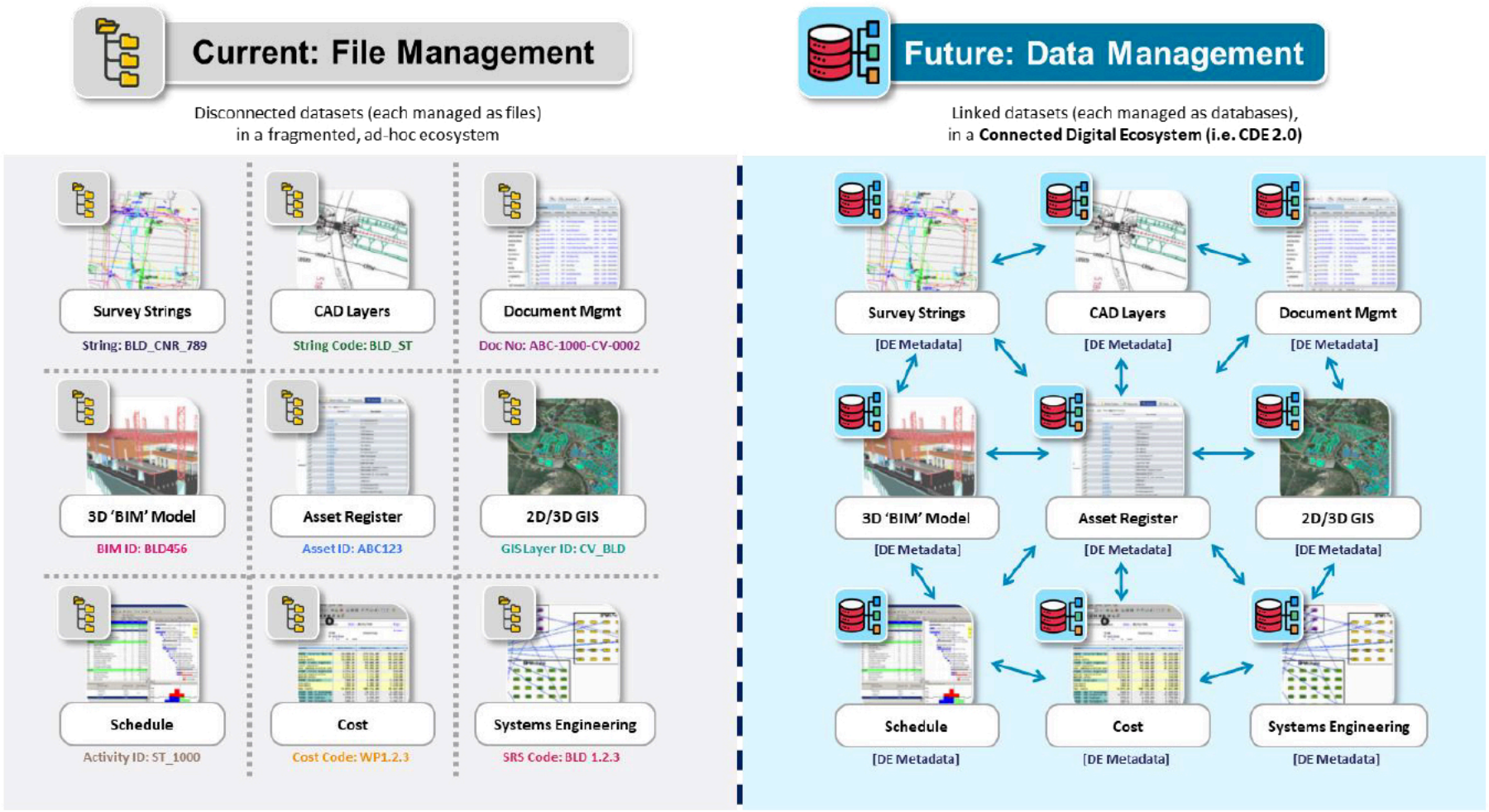


Figure 2.3: Transition from siloed electronic files to a digital ecosystem of linked databases

See Figure 2.3, on how DE works to address these siloes by defining consistent metadata for all datasets and effectively supports the digital ecosystem of linked databases.

The benefits of DE are wide-ranging across a broad range of use-cases, stakeholders, and lifecycle stages. Some of the key benefits are provided in Appendix A of this Standard.

2.4 Principles for digital engineering

DE provides a range of new business outcomes that can be grouped into general principles (see Table 2.3). This list of 12 key principles has been developed based on in-depth research of 10 government led digital transformation programs from across ANZ and the UK.

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No.	Theme	Principle	Details
1	Interoperability	Adopt open and interoperable formats (where possible)	To ensure data is consistent, flexible and scalable, and will maximize possible use-cases, applications and technologies (both current and future)
2	Governance	Actively manage and promote data custodianship	Through clearly defined owners, authority, responsibility, policies and regulation
3	Quality	Specify data with defined quality requirements	That allows users to derive meaningful insights and make more informed 'data-driven' decisions, by ensuring data is accurate, comparable, verifiable, fit-for-purpose and complete
4	Value	Manage data as an asset	Through mature digital capability and business integration, to realise benefits such as 'return-on-investment', ongoing business value, process improvement and public good
5	Collaboration	Enable digital collaboration and data federation	By creating an open ecosystem of interconnected and consistently managed databases
6	Capability	Normalize data literacy and foster digital dexterity	Through appropriate roles and resources, knowledge sharing and continuous improvement of business capability
7	Re-use	Maximize opportunities for data re-use	By producing datasets that are verifiable with transparent and preferably automated assurance processes, to avoid single use or uncesssary duplication
8	Secure	Protect the digital ecosystem	Through secure systems and controls that provide role-based access, traceability and real-time monitoring (with particular focus on data deemed to be safety critical, personal, confidential, classified and/or commerical in confidence)
9	Trust	Instill trust and confidence in data quality	By assigning primary sources for all shared datasets, including ownership, provenance and status
10	Accessibility	Enable data accessibility	Through platforms that support input, sharing and federation, from multiple physical locations
11	Automation	Eliminate or minimize manual data manipulation	Using more automated processes to create, manage and exchange shared data
12	Visualization	Create datasets that enable visualization	Using methods such as object-based modelling, spatial data or other related means, to support interrogation, association, interaction and collective understanding

Table 2.3: Principles for DE

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2.5 How does digital engineering work?

DE enables effective data management by creating digital project deliverables in open formats and tagged with standardized metadata (such as asset classification), to ensure semantic interoperability across all project disciplines (see table 2.4 and figure 2.4).

Enabler	Details	Examples
Open data formats	Non-proprietary file formats to enable open exchange and federation of project datasets	BIM - .ifc Office - .docx, .xlsx, .csv Documents - .pdf, .txt Images - .jpg, .png
Metadata	Common semantics (taxonomy, ontology and ERD) to enable interoperability between parties over the lifecycle	Asset/location classification such as Uniclass CAD - Drawing title block and line types BIM - Object tagging Cost – CBS such as ICMS Framework Asset data - Product data sheets
Connected digital ecosystem (CDE 2.0)	A digital ecosystem of linked databases, that manages and exchanges datasets & metadata, using consistently structured data architecture, to ensure semantic interoperability over the asset lifecycle	Multi-disciplinary infrastructure projects Asset management platforms Digital twin ecosystem

Table 2.4 Key Enablers for digital engineering

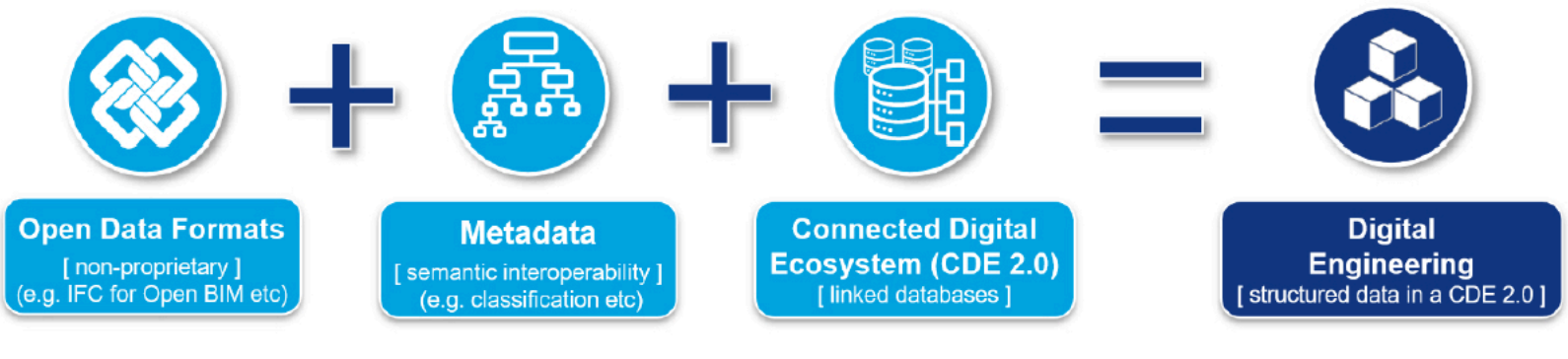


Figure 2.4: Key Enablers for digital engineering

This approach provides context to datasets and enables connected business processes through structured data. DE ensures all project datasets are procured, created, managed, and exchanged consistently in a digital ecosystem of databases – otherwise known as the connected digital ecosystem (CDE 2.0)

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Structured data from across project deliverables can be easily recalled based on attributes such as:

(a) specific assets;

(b) asset systems;

(c) asset locations;

(d) project lifecycle stage;

(e) responsible parties.

DE therefore enables projects to easily recall information, associate data and gain critical insights on specific assets, multidisciplinary projects, multi-stage programs or even overall infrastructure networks.

It is important to note that most of the technology already exists. The concepts articulated above are not necessarily new to the rail industry and have now been proven globally on large-scale transport infrastructure projects.

DE recognizes the importance of maintaining project specific datasets within their respective specialist software platforms. It aims to redefine the data structure of each deliverable by establishing a common data model and enabling master data management of information deliverables in an effective ecosystem of linked databases. This essentially defines the key principle of the CDE 2.0.

2.6 Data management

2.6.1 General

While BIM has been the catalyst for change, the more significant and transformative developments have been focused on building data management capability. Data management is a critical component for all sectors, with most modern organizations now proactively managing data as an asset.

2.6.2 Historic file management

Traditionally organizations have procured information as files and records, with data stored and managed in siloed systems. Data has typically been created for single-use purposes only, with little-to-no consideration for how it could provide benefit to other parties or how it could be re-used to support business decisions over the full asset lifecycle. Furthermore, the storage of data in segregated or siloed systems has also impacted the ability for others to find records, limiting the ability for data to be accessed, associated or re-purposed for value add business activities.

Most importantly, this approach does not permit data to be properly managed as an asset, and limits potential opportunities for further value to be unlocked across an organization or over the full asset lifecycle.

2.6.3 Evolution to modern data management

The digital approach to data management moves away from single-purpose or project-centric information records. Progressive organizations are now focusing their attention on re-designing their data structures, to enable data to be managed in ‘business-centric’ database systems (see Figure 2.5).

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