KiwiRail

Digital Engineering Framework

Version 4

Document Control

Version History

Version Number	Version Date	Summary of Changes	Author
1.0	6/06/2020	Updated from WMUP Pilot to KR wide. Includes post CDE development documentation.	K Niven & A Lyon
2.0	7/01/2021	Updates to sections 3.2, 4.5 and 4.6	D Jannings
3.0	22/03/2021	Refinements and updates shown in blue text with additional information relating to Revizto and a new AIR.	A Lyon & D Jannings
4.0	5/08/2021	The framework has been broken down into a suite of documents. This document will now cover KiwiRail's digital engineering vision and detail will be covered in supplementary documents	D Jannings
4.1	13/05/2022	Included reference to new Digital Design Management Guidance Note	N Wagner

Reviewers' Name

Reviewers Name	Date	Signature	Position
D Jannings	13/05/2022		Digital Engineering Programme Manager

Signed off by Approvers

Approver Name	Date	Signature	Position
A Lyon	13/05/2022		Programme Director – Digital Engineering

Final Distribution

Name	Position
File	-

Contents

1 Overview

1.1 PURPOSE

The purpose of this document is to provide an overarching guidance for digital engineering (DE) at KiwiRail. The genesis of this document was developed within the Wellington Metro Upgrade Programme which was considered KiwiRail's BIM Pilot. Since then, KiwiRail is scaling its adoption of digital engineering across capital projects.

Version 4 of the DE Framework splits the previous version of the document into a series of documents that focus on specific areas, rather than one document to cover everything. This segmentation is conveyed in section 3 in detail.

The purpose of this document is:

- To outline KiwiRail's DE vision and overarching objectives
- To outline how the DE Framework fits within KiwiRail's DE transformation programme plan
- To provide guidance as to where specific detail can be found in other documentation
- To provide a high-level outline of the adoption of ISO19650 and how these principles are being utilised in the implementation of digital engineering
- To provide guidance as to what the KiwiRail digital way of working encompasses
- To provide an overview to KiwiRail's approach to digital engineering training for both internal and external stakeholders

1.2 RAIL INVESTMENT

KiwiRail is in the midst of an exciting transformation on the back of Government investment of more than $4 billion since 2017. This funding is enabling KiwiRail to deliver more than just physical assets, as the capital projects create an opportunity to also transform the way we work.

The Government outlined its 10-year vision for rail through the NZ Rail Plan. This also represents a historic change in the way the rail network is planned and funded in New Zealand. In July 2021 the first Rail Network Investment Programme (RNIP) came into effect which sees Waka Kotahi NZ Transport Agency fund rail infrastructure from the National Land Transport Fund (NLTF), providing a long-term pipeline of infrastructure investment. This is critical for funding and planning investment in long life assets. The RNIP will identify the key rail investments required to bring our rail network back to a resilient and reliable state. These investments are aimed at shifting more freight from road to rail, extending options for passenger rail, and unlocking development potential in our communities.

The use of digital engineering, and a focus on the value of data and information forms a core part of KiwiRail's strategy to enable stronger economic and social connections for New Zealand.

2 Digital Engineering Strategy

2.1 ALIGNMENT TO KIWIRAIL STRATEGIC OBJECTIVES

All digital engineering initiatives are implemented to align with KiwiRail's strategic objectives. These initiatives will provide the foundational data to support wider business transformation. It will do this by developing people and processes, and implementing technologies that primarily support capital programmes, but ultimately enable the business to move into a digitised future.

Digital Engineering will enable the following outcomes:

Commercial Delivery	People & Safety	Capital Projects Delivery	Sustainability, Innovation & Collaboration
• Enable data driven commercial decision making • Improved productivity in the construction of new assets • DE tools & processes enable risk to be manged at the right time in the asset life cycle	• Keeping our people safe through the scaled implementation of Machine Avoidance and other DE technologies • Develop our "digital way of working" on projects that aligns with the wider high-performance high engagement culture	• Structured and reliable asset information • Coordinated designs produced in a single source of truth location • Connected technologies that drive delivery efficiencies	• Carbon reduction through the improved quality of digitised assets • An environment for innovation to thrive within the business • Industry leading, chairing the Digital Asset Owner and Committee for Digital Engineering in NZ forums

2.2 DIGITAL ENGINEERING VISION

To successfully deliver the capital works portfolio and to support the growth of the wider business, and AEC industry as a whole, KiwiRail acknowledges the need to embrace continuous improvement in how it operates. The Digital Engineering Programme vision recognises the important role KiwiRail plays in the New Zealand AEC industry and the programme seeks to

> **Pioneer KiwiRail's digital journey to transform the industry.**

2.3 DIGITAL ENGINEEIRNG OBJECTIVES

At the beginning of the KiwiRail BIM pilot the following objectives outlined below were developed. To date throughout the evolution of KiwiRail's digital maturity as an asset owner these objectives have been re-evaluated to confirm that still hold true and align with KiwiRail's long term strategy. The objectives have not been changed since their inception.

The digital engineering objectives are:

- **Provide a place where people can access and consume data**

  This is known as the common data environment (or CDE) and as well as being a key element in delivering a BIM project it was also seen as a tangible quick win for the pilot. By creating a scalable CDE during the pilot the project teams had access to what information they needed when they needed it. The wider business was also able to access data that had previously required specialist software to view by using a cloud-based solution.

- **Reduce risks during the construction phase**

  The value proposition that is easy to understand and measure. A BIM framework can offer value far beyond the construction phase but it can be hard to quantify these benefits as they are made up of many small slices of benefit over the whole life of an asset. By reducing the recurrence of variations (and therefore cost) arising from clashes and a lack of information, the pilot was able to justify a business case for working this way. The first physical works contract on the pilot achieved a 10% saving on the contract value.

- **Create a rich and accurate as-built record of the asset**

  It is well known and accepted that the as-built process is fundamentally deficient. KiwiRail has many examples where constructed assets are not entered into the asset management system, or if they are it is through a manual data entry process. Our contracts do not reflect the value that asset data holds, and as-builts are left to the closing stages of a project. The pilot sought to change this by focusing on rich data that is connected and can be used and re-used without having to re-create it (as is the case with red pen mark ups). Digital models and asset attributes were the required as-built format as this data could be more easily verified for accuracy, and the data entry could be automated. The pilot also moved away from as-builts at the end of a contract, instead requiring as-builts to be provided monthly as part of the payment claim process. This demonstrated to the supply chain the value that data holds for KiwiRail.

- **Increase efficiency in the way we work**

  By moving the projects to a data centric way of working the pilot was able to build a foundation that innovation could grow from. One example of this is the machine avoidance (or digital shields) solution that was developed where 3d models are loaded into an excavator via an onboard computer, these models act as shields for existing assets and if the excavator comes too close the real asset then the computer shuts it down. By implementing this the pilot team were able to increase productivity by 20-30% on their earthwork's operations.

2.4 DIGITAL ENGINEERING PROGRAMME PLAN

To implement digital engineering across capital projects, KiwiRail have developed a Digital Engineering Programme Plan. The programme plan provides a structure to deliver digital engineering initiatives at scale in a consistent manor. The programme plan aligns to the Managing Successful Programmes (MSP) framework. The DE programme has been separated into 4 tranches to deliver the desired transformational change.

The DE programme plan tranches are as follows:

Tranche 1 – Test

Continue the work on the Wellington Metro BIM Pilot, feed lessons learnt into our framework and other projects via the DE Team.

Tranche 2 – Scale

Using the lessons learnt, processes and tools, scale the digital way of working across the CPAD portfolio with a focus on streamlining the design process, reducing construction risk, and improving our digital assets. Develop a change process to ensure success.

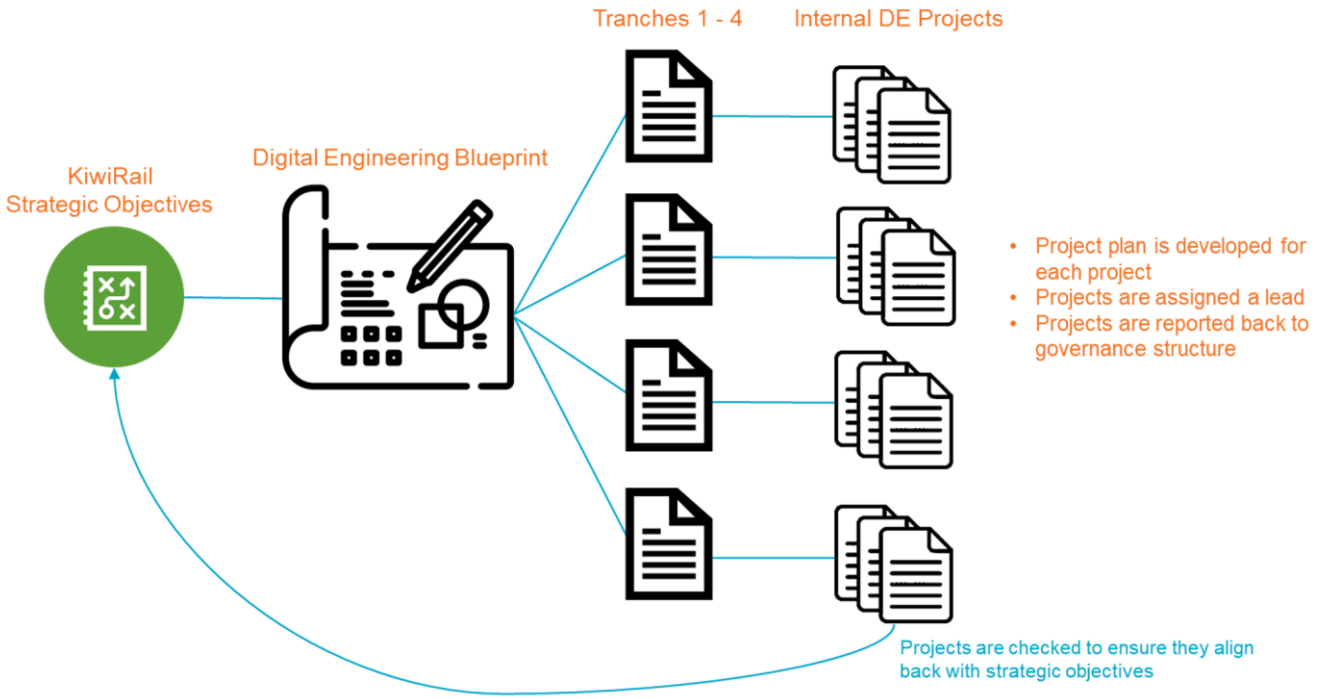
Tranche 3 – Advise

Help the wider business to test what BIM and DE can do for them. Give more people the experience that the projects create the opportunity for. Inspire opportunities for the future state.

Tranche 4 – Transform

Help the business develop the vision for the future state of DE based on the experience gained from Tranches 1-3. Set up and implement a wider change programme.

The following diagram provides an overview as to how the DE programme plan works. Further detail within the DE programme plan be provided by the KiwiRail digital engineering team. A series of internal digital engineering projects have been developed for each tranche. This enables DE initiatives to be tested and then scaled in a structure way that ensures they meet business objectives.



2.5 TRANSFORMING THE INDUSTRY

As outlined in section 2.2, KiwiRail's vision is for the digital engineering programme of works is to pioneer our organisations digital journey and ultimately drive industry change. The introduction of a government mandate on the use of BIM and information management in the UK in 2011 has led to a wide range of literature on the potential benefits.

Digital engineering offers a range of new capabilities and benefits for project stakeholders across the complete asset lifecycle. A recent report published by the Centre for Digital Built Britain[1] analysed eleven case studies where Digital Engineering had been implementation at various stages across the asset

[1] The value of information management in construction and infrastructure sector Centre for Digital Built Britain, 2021.

lifecycle. The report includes evidence which suggests the use of Digital Engineering and Information Management provides $5.10 and $6.00 of labour productivity for every $1.00 invested.

Kiwirail acknowledges that in order reap the benefits of digital engineering it must support its supply chain and wider industry adopt new technologies and ways of working. It also acknowledges a responsibility as a state-owned enterprise asset owner organisation that it must be a leader and have a clear voice in driving the digitalisation of the infrastructure and construction sectors enabling benefits for all New Zealanders.

2.6 DIGITAL ASSETS

A recent report titled Flourishing Systems published jointly by Centre for Digital Built Britain and the Cambridge Centre for Smart Infrastructure[2] re-envisions a people focused and systems-based approach to infrastructure. It recognises that infrastructure is a complex interconnected system of systems that must deliver continuous service to society.

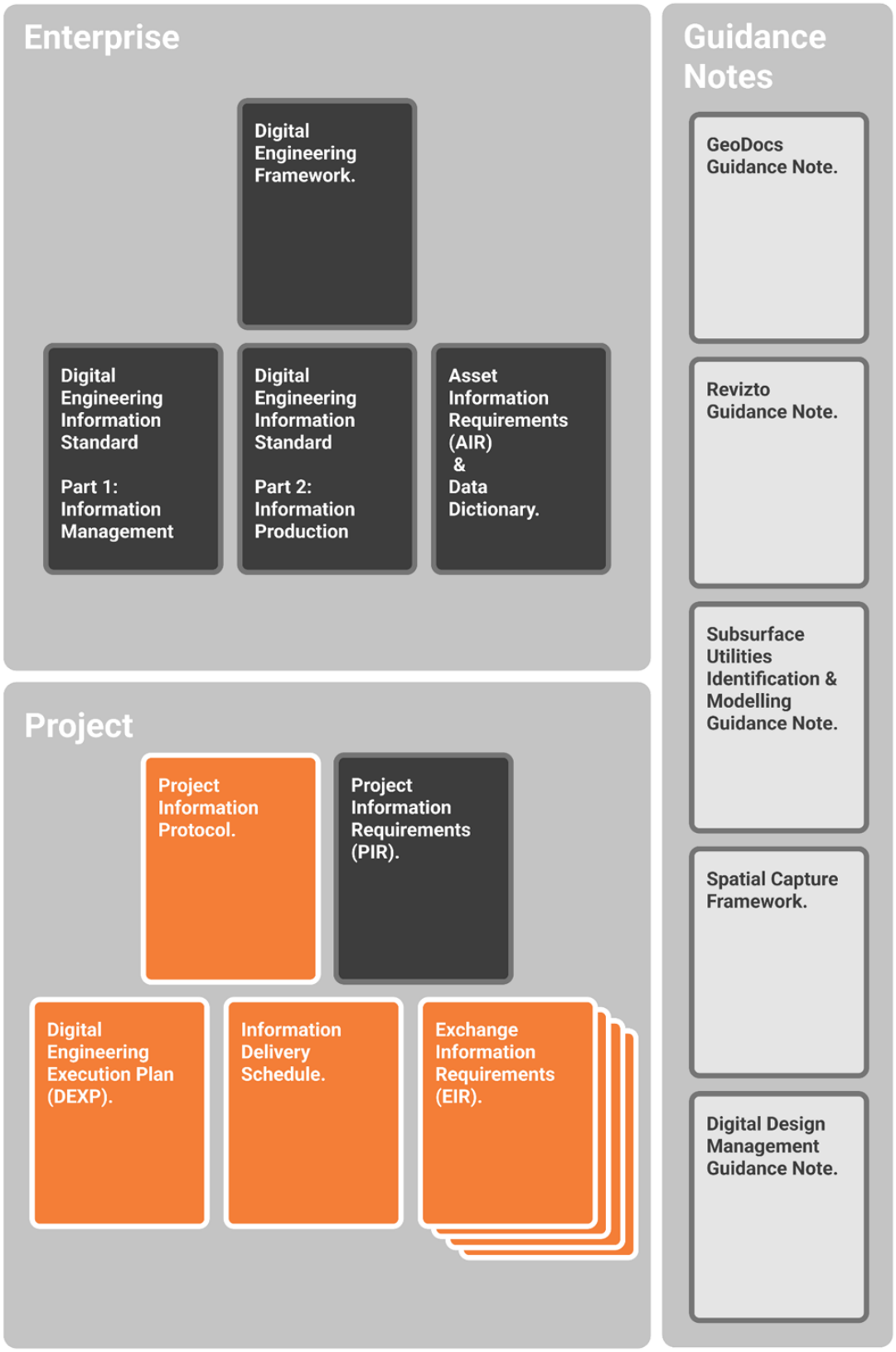
Infrastructure must get smart to meet economic, social, and environmental outcomes. To achieve this, digital assets of physical assets must be recognised as genuine assets. The KiwiRail DE team are the custodians of the digital assets through until they are handed over to asset management and operational teams. The KiwiRail DE team ensure all DE initiatives that are implemented for wider business benefit beyond a capital project are considered as a connected collection of interrelated and interdependent parts of a complex system.

[2] Flourishing Systems Centre for Digital Built Britain and the Cambridge Centre for Smart Infrastructure, 2020

3 Framework Documents

Version 4 of the DE Framework is segmented into a suite of documents. This enables specific technical information to be covered in a specific document, for the right audience.

The following diagram and table convey the suite of the framework documentation.



Document	Purpose
Enterprise	
Digital Engineering Framework	To outline KiwiRail's DE vision and overarching objectives. To provide guidance as to where specific detail can be found in other documentation.
Digital Engineering Information Standard – Part 1 (Management)	Outlines the process of how information is managed and consumed within the context of a project.
Digital Engineering Information Standard – Part 2 (Technical)	Outlines the details of how information should be produced by an author to meet KiwiRail's information requirements.
Subsurface Utilities Identification and Modelling Guidance Note	How to identify, model and transmit subsurface utility information to KiwiRail within a project.
3d Spatial Data Capture Framework	Outlines how spatial information is to be captured, created, reference, and controlled.
Asset Data Dictionary	Outlines all the possible asset types, and their associated attribution requirements.
GeoDocs Guidance Note	Supplementary document which covers off the correct usage of the CDE, including details of the background processes for those wanting additional detail.
Revizto Guidance Note	How KiwiRail standardise the use of Revizto across the KiwiRail projects portfolio.
Digital Design Management Guidance Note	Outlines how the DE tools & processes of KiwiRail's DE Framework can be embedded within the design phase of a capital project to support & enable design management fundamentals.
Project	
Digital Engineering Execution Plan (DEXP)	Outlines how Digital Engineering will be completed throughout the scope of the engagement, responding to the requirements outlined in the EIR. Outlines the roles and responsibilities within the supplier's organisation and can be used as a form of assessment for the tender submission process. Pre-contract is to be prepared by the supplier, and the post-contract is collaboratively developed between KiwiRail, its partners and the supplier.
Project Information Protocol	Provides additional clauses which enable the scope of Digital Engineering to be amended to the contract.
Information Delivery Schedule	Details the level of information need, required against asset data dictionary classifications, throughout the project lifecycle. Specifies the types of asset classifications expected throughout the scope of the project.
Project Information Requirements (PIR)	Includes general project information, including scope, stakeholders and high-level delivery milestones. Outline the overarching project specific digital initiatives for implementation on the project. PIR explain the information needed to answer or inform high-level strategic objectives within the appointing party in relation to a particular built asset project. PIR are identified from both the project management process and the asset management process. (extract from ISO)
Exchange Information Requirements (EIR)	Breaks down the overarching project objectives in the Project Information Requirements into the requirements of each engagement within a project at a detailed level. Details the expectations of information delivery against the project milestones. EIR set out managerial, commercial, and technical aspects of producing project information. The managerial and commercial aspects should include the information standard and the production methods and procedures to be implemented by the delivery team. (extract from ISO)

4 Information Management

4.1 ISO 19650

The ISO 19650 standard is an international standard for managing information over the whole life cycle of a built asset using building information modelling (BIM). It contains all the same principles and high-level requirements as the British **BIM Level 2** standard and is closely aligned with the current UK PAS 1192 standards. In Q1 2019 the first two international standards of the series were published and followed up with by the third in Q3 2020. The standards in the series are as follows:

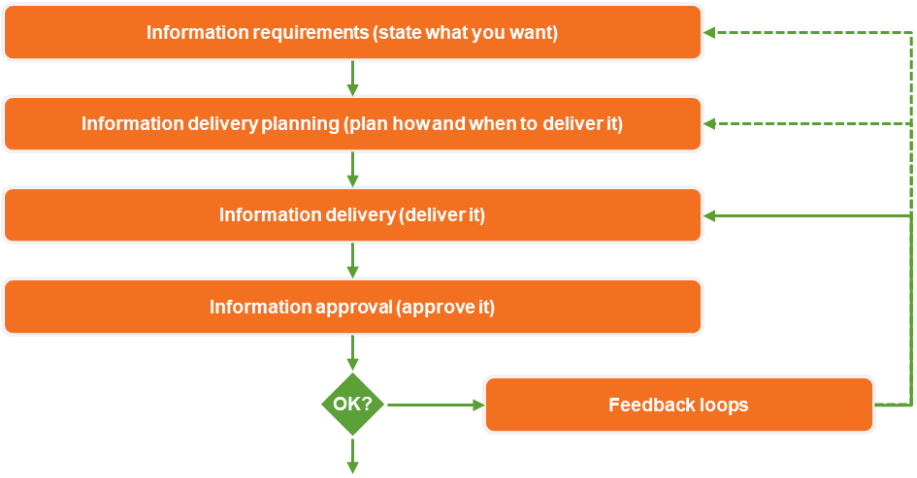
ISO 19650-1: Organization and digitisation of information about buildings and civil engineering works, including building information modelling -- Information management using building information modelling: Concepts and principles

ISO 19650-2: Organization and digitisation of information about buildings and civil engineering works, including building information modelling -- Information management using building information modelling: Delivery phase of the assets

ISO 19650-3: Organization and digitisation of information about buildings and civil engineering works, including building information modelling -- Information management using building information modelling: Operational phase of the assets

The KiwiRail Digital Engineering Framework implements the ISO principles, through the following:

- Organisational Digital Objectives underpinned by requirements for collaboration and effective team working
- In the way we produce, share, and manage information
- A standards driven information framework
- A Common Data Environment



4.2 ORGANISATIONAL INFORMATION REQUIRMENTS (OIR)

The following points define the BIM Objectives or organisational information requirements (OIR) for KiwiRail. These have been developed to align with the overarching business goals, and to address deficiencies in the traditional project delivery model.

- To have access to all project data federated in one common data environment.
- To provide freely accessible as-built asset information in an environment/format that does not require specialist software.

- To ensure information is re-usable without reworking or rebuilding datasets throughout the asset lifecycle (or put plainly stop focusing on the production of ‘dead end’ data such as drawings when we will be better served by the exchange of geometric and asset data that drawings can be derived from).
- To improve underground service information that will support KiwiRail’s Permit to Dig process through known location and accuracy of data.
- To provide rich asset data that can be analysed for performance trends (e.g. identifying premature decaying sleepers specific location & quantity).
- To maintain and retain asset information for future procurement events (reducing inefficiency associated with loss of data through asset life cycle).
- To improve accuracy in cost estimating and assist in determining whole life cycle cost of assets
- To hold safety in design information against specific assets and ensure future work is cognisant of the risks and hazards.
- To reduce the occurrence (and therefore cost) of re-work or clashes during construction/maintenance/renewal activities.
- To improve internal and external stakeholder engagement through 3d visualisation.

4.3 ASSET INFORMATION REQUIREMENTS (AIR)

The KiwiRail Asset Data Dictionary outlines the asset information that is required to meet the objectives of KiwiRail with regards to its vertical and horizontal assets. This information has been derived from KiwiRail’s asset model (held in Maximo) and has been recently developed to incorporate KiwiRail’s vertical assets (i.e. buildings, property, and maritime assets). Data Dictionary is a separate document as outlined in section 3.

4.4 PROJECT INFORMATION REQUIREMENTS (PIR)

The PIR will be developed for each individual project, however the KiwiRail PIR template will be used as the starting point. The PIR will be informed by the OIR, therefore explaining the information needed to answer or inform high-level strategic objective. PIRs are derived from both project management and asset management processes.

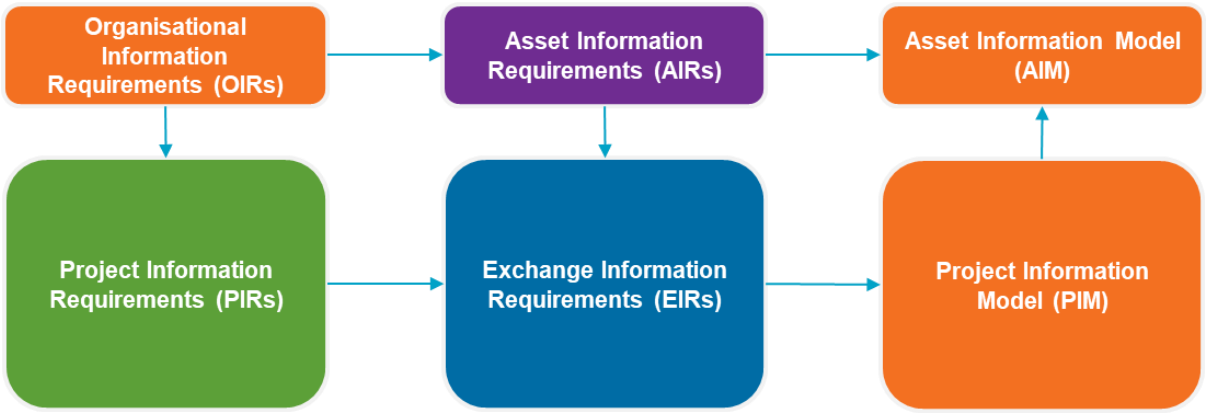
4.5 EXCHANGE INFORMATION REQUIRMENTS (EIR)

The EIR will be developed for each individual project, however the KiwiRail EIR template will be used as the starting point. The EIR will be used to determine what information (models, documents, and data) is required at each project stage, and shall be used by suppliers to inform the development of pre-contract BIM execution plans (BEPs) during the procurement phase through to the development of project BEPs after contract award.

The EIR for a project will fundamentally answer the following questions:

- Where will information be shared (i.e. the Common Data Environment)?
- Who is sharing the information?
- What information is needed?
- When the information is needed?
- How will the information be used?
- Why the information is needed?

The following diagram conveys how the requirements come together to produce information:

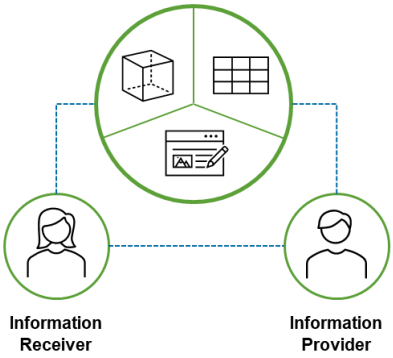


5 KiwiRail Digital Way of Working

The implementation of digital engineering across capital projects is changing the way we work at KiwiRail. This change requires a collaborative approach to the production and exchange of information from both KiwiRail and its supply chain.

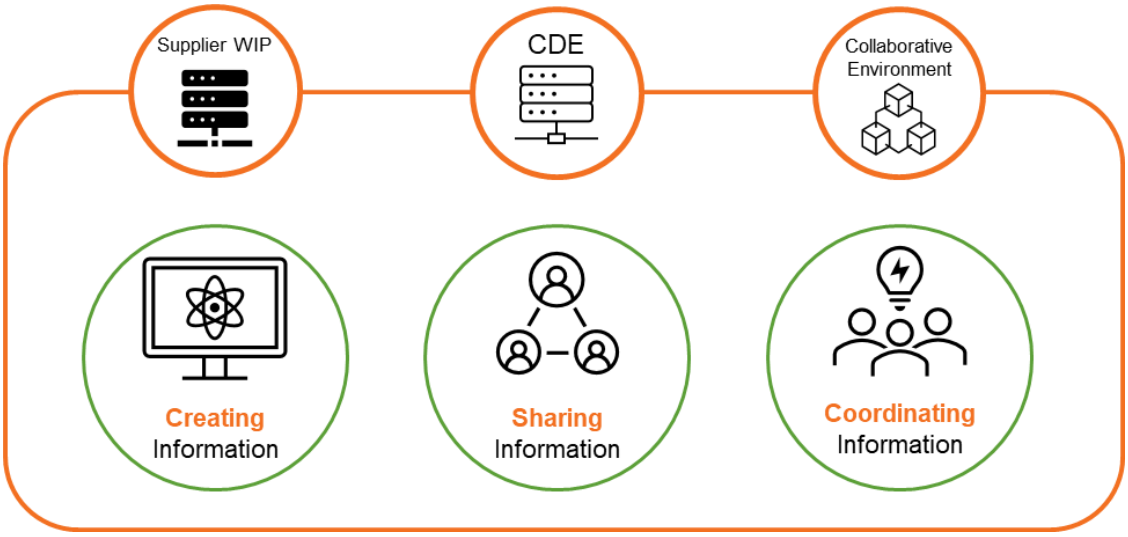
5.1 THE COLLABORATIVE PRODUCTION OF INFORMATION

How and what information is produced is critical to ensuring information is used in an efficient way. As a receiver of information KiwiRail will articulate our information requirements to our providers of information (e.g., our supply chain) via our AIR, PIR & EIR as outlined in section 4.



To enable the collaborative production of information KiwiRail as implemented two key enabling technologies:

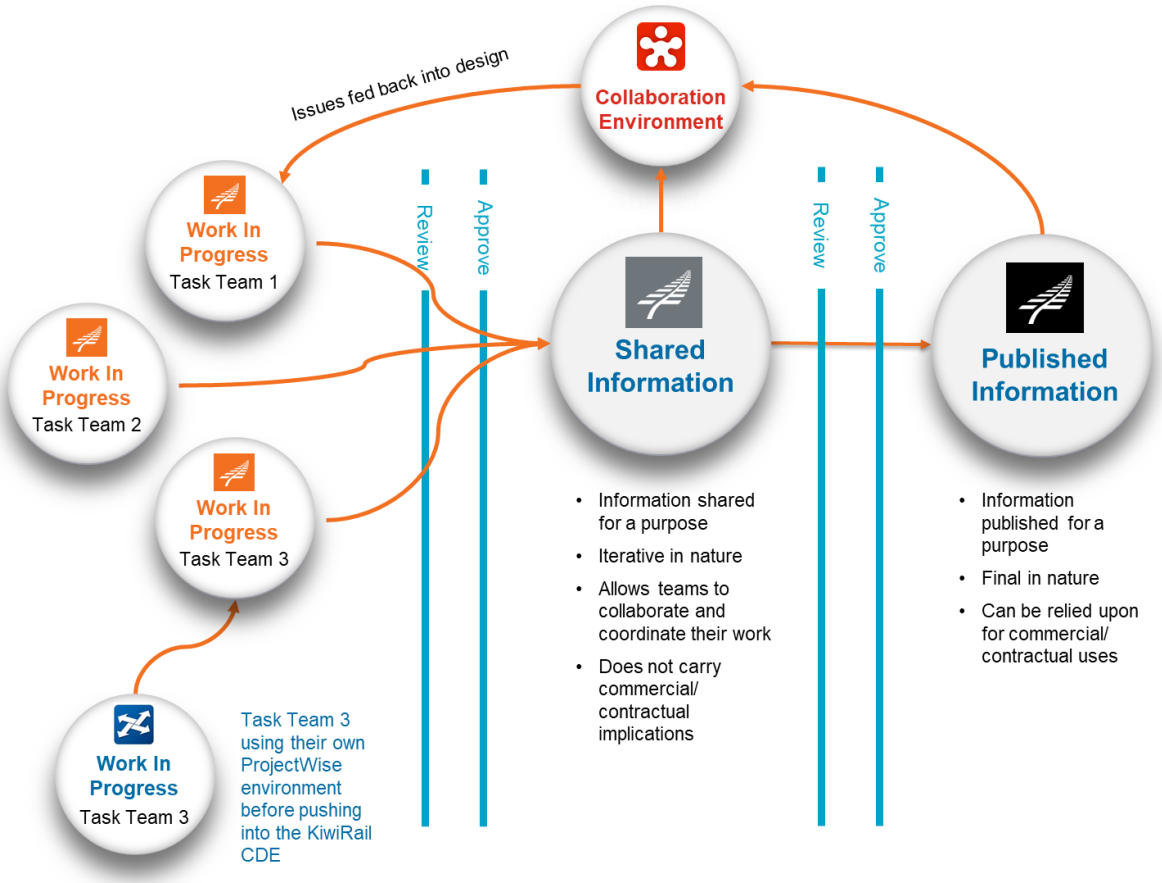
- The CDE aligned to ISO19650 – Where we gather the information together
- The use of Revizto as a collaboration platform to enable virtual design & construction (VDC) – Where we gather the people together



5.2 TYPCIAL PROJECT INFORMATION WORKFLOW

The implementation of our CDE and collaboration environment enable coordination, communication, and collaboration to happen on our capital projects. The below diagram outlines what this information workflow looks like at a high level. Details around information workflows may differ and be project specific however, the following key principles must be upheld:

- Information must be in the CDE before it is available in the collaboration environment
- Information must be produced, shared, and managed in alignment with ISO19650
- Task teams will work collaboratively to resolve as many issues as possible within the collaborative environment to reduce the number of formal and contractual correspondence required on the project e.g., RFIs.



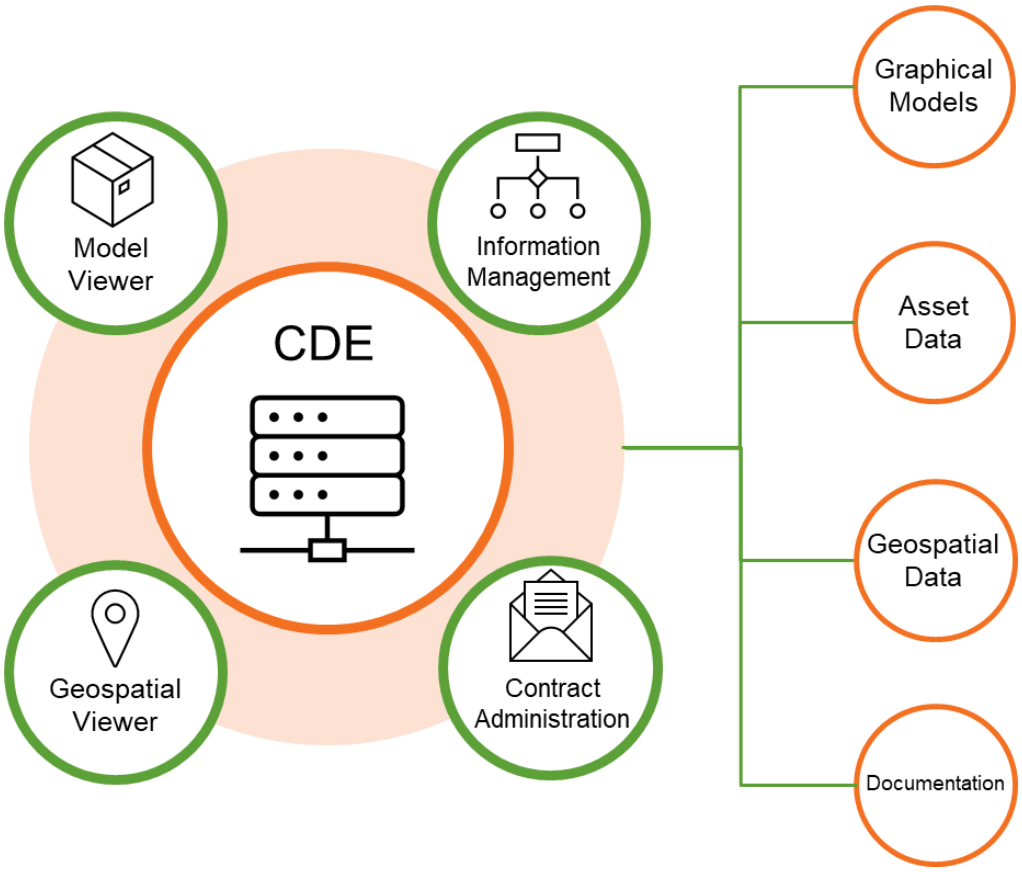
5.3 THE COMMON DATA ENVIRONMENT

To support our digital objectives KiwiRail have implemented a Common Data Environment (CDE).

The CDE provides a digital platform where design models, survey data, and other digital engineering outputs can be hosted and federated across design and construction teams. The CDE will allow KiwiRail to consume and display design material that has traditionally been lost due to a lack of software and licences required to work with multiple specialist file types, specifically including point clouds and other survey information, design models, and project documentation.

The CDE will be used to control the production and sharing of project information throughout the project lifecycle (both for design coordination and construction updates) and will host the final sets of information (including for construction and asset information models (AIM)). The platform will provide an ongoing repository of capital project information and will provide inputs to organisational asset management systems.

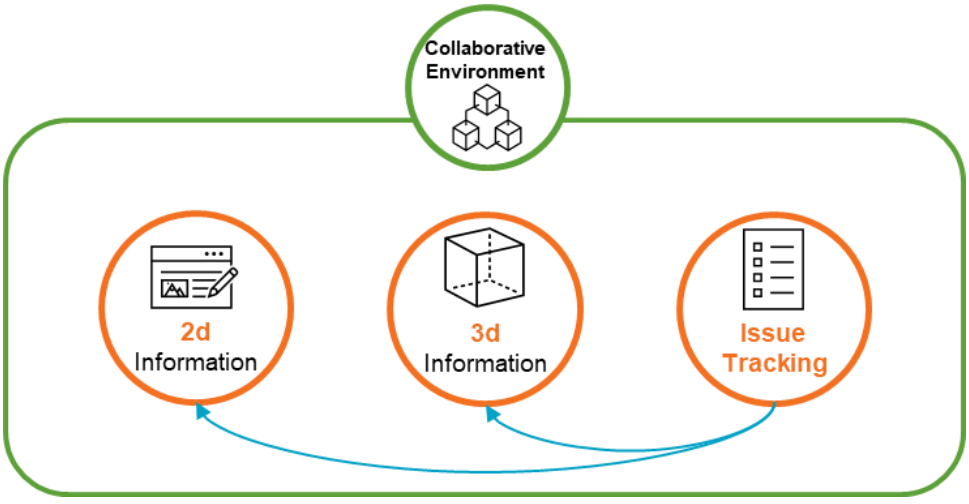
KiwiRail's CDE system is GeoDocs and is being implemented across capital projects. More detailed information about GeoDocs can be found in the GeoDocs Guidance Note document.



5.4 THE COLLABORATION ENVIRONMENT

While the CDE acts as the repository for sharing and storing information, Revizto is used as a VDC tool to enable teams and stakeholders to have meaningful input to the project lifecycle. All 2d and 3d information produced on the project is to be pushed at agreed milestones from the CDE to the project's collaboration environment. This will then act as the single source of truth for coordination.

All project coordination issue tracking will be completed in the collaborative environment with issues being assigned to a visual representation. This enables tasks teams to all be looking at the same information when working together to resolve and coordinate design and construction activities.



It is important for suppliers to recognise that the Revizto environment represents an aggregation of information and data that will pass through the lifecycle in a tangible form. Issues raised during the design process, including safety in design, will pass through to construction teams by issuing the Revizto project during procurement. Similarly, the issues raised in construction along with design issues will pass into operations as part of the as-built process, to reduce the likelihood of information and knowledge being lost.

The Revizto environment is not purely a tool for designers and constructors, other stakeholders may be invited into the environment so they can have a meaningful input at the right time, for example:

- Consenting teams advising areas of importance to allow designers to reduce the impact of the design.
- Operations teams explaining how they work to ensure the solution meets their needs into the future.
- Community engagement teams to facilitate conversations with our neighbours and ensure they better understand how we impact them.

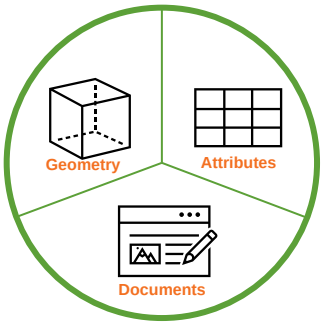
5.5 INFORMATION METADATA

The implementation of our CDE and collaboration environment enables a data driven approach to the production, sharing and management of information. This changes the way we think about producing information and how it could be used downstream.

Metadata is a set of data that describes and gives information about other data. The accuracy and relevancy of this metadata enables our digital assets to hold currency and become valuable assets to our organisation as described in section 2.5. All metadata requirements outlined in the supplementary documents within our DE Framework (for example information standard) need to be adhered for KiwiRail to enable a digitised future.

5.6 PROJECT AND ASSET MODELS

Two different types of information models are created during the asset delivery phase, being Project and Asset information models. The term model in this case refers to 3d geometric representations, as well as attributes, and documentation.



Project Information Model

A project information model (PIM) is what information is produced during the delivery phase and is what ultimately contributes to or forms the entirety of what is known as the asset information model (AIM), which is used for operation and maintenance.

The project information model is progressively developed as two key deliverables. The first key deliverable is known as the design intent model, produced by the professional designers, and the second key deliverable is known as the virtual construction model, which is developed by the specialist designers and construction teams, using the design intent model as a reference.

As the Design Intent Model is the first iteration of the Project Information Model, it is important that it meets the relevant project information requirements. However, the delivery teams producing the Design Intent Model may have their own additional requirements for information, needed to fulfil their scope of services. The same goes for the Virtual Construction Model. Delivery teams may also have their own additional requirements for information, needed to fulfil their scope of services. It should also be recognised that each iteration is producing information that is passed to the later stages of the asset delivery, therefore teams need to consider the information needs of others; information must be created for a purpose defined by the receiver.

In the case of the 3d geometric representation (or 3d model) this information forms the basis for all the collaboration activities and task teams must author information in 3d. To enable coordination and collaboration the delivery team models will be federated. Federated models provided by design, and construction teams will be uploaded to the CDE.

These models will be multi-discipline and (in the case of the As Built model) will provide the final 3D representation of the asset to be handed to the KiwiRail Asset Management team

5.7 OUR NEW WAY OF WORKING

The adoption of digital engineering requires us to change the way we work and where we focus our efforts during the life cycle of a project. It requires us to invest more effort upfront to produce a rich digital asset that has been coordinated in the digital world before we build it in the physical world, ultimately reducing risk and cost during constriction.

The following table outlines the key areas of change during the life cycle:

Lifecycle phase	Traditional approach	New way of working
 Information Gathering	Upfront investment in existing conditions is not prioritized as risks are planned to be passed to the construction team.	Existing conditions are modelled in detail to allow integration with the design models. Upfront costs are higher.
 Design	The design is completed in silos with little opportunity for interdisciplinary coordination. Client reviews are limited to milestones.	The design is continually shared to disciplines can iterate the design together. Regular model federation and issue tracking ensures clashes are addressed.
 Review	Engineering review is undertaken on a large number of drawings (easily 200+ sheets for a $30M project). Review is limited to information within the drawing. A multitude of errors can be hidden by 2d outputs.	Engineering review is undertaken within the model at regular intervals throughout the process. Issues are raised and tracked within the model. Stakeholders (non-technical) have a greater understanding of the form and function of the design.
 Construction	As the project moves to construction the issues hidden within the drawings are unearthed. These lead to cost and time escalation.	Models and information passed to the construction phase is accurate and reliable and additional data is added as required.
 As built	Design drawings that are known to be wrong are amended with red pen to provide a record of construction. Detail is missing and, in some cases, incorrect.	The continual updating of data means as-builts can be kept live throughout the build and asset information can be passed across before the job is complete.
 Maintain	Asset management is hampered by a lack of useable data, or data that cannot be trusted. Costs are incurred to establish what should have been known.	Structured data allows for analysis to be undertaken, and data driven decision making to prevail. Models can be connected to IOT sensors to create a digital twin.

6 Education and Training

As KiwiRail scales the implementation of digital engineering it will provide training to support the adoption of new tools and processes. To date training will be focused in three key areas, these are:

6.1 ISO19650 – INFORMATION MANAGEMENT

The KiwiRail DE team will provide ISO19650 training for internal delivery team members. This enables our people to understand the principles of the standard and implement them across their projects. KiwiRail will also support the adoption of greater knowledge and understanding of the standard across industry and our supply chain.

6.2 GEODOCS – TECHNICAL USE OF THE TOOL

The KiwiRail DE team will provide GeoDocs training for all people both internal and external who are required to use the platform. This training will entail guidance on the basic functionality of using the platform and how it aligns with ISO19650 workflows. The training will be given as both one to one and/or one to many training methods as appropriate.

6.3 REVIZTO – TECHNICAL USE OF THE TOOL

The KiwiRail DE team will provide Revizto training for all people both internal and external who are required to use the platform. This training will entail guidance on the basic functionality of using the platform so they can collaborate with project team members. The training will be given as both one to one and/or one to many training methods as appropriate.


KiwiRail