Spatial Capture Framework

Version 2

Document Control

Version History

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1.0	11/06/2021	Initial publish for project use	M Pinkerton (Aurecon)
2.0	09/12/2021	General Updates	M Pinkerton (Aurecon)
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Reviewers' Name

Reviewer Name	Date	Signature	Position
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Signed off by Approvers

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Final Distribution

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File	-

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1 Overview

1.1 PURPOSE

Spatial datasets representing the existing built environment are a vital component of the digital engineering process, providing both site context as well as physical linkage between elements of a virtual model and their real-world location.

KiwiRail's contractors have the responsibility to document the position of all assets they install or modify whilst working on a KiwiRail site, therefore the responsibility of adherence with this framework extends beyond just surveyors and geospatial professionals.

This document therefore sets out the requirements for establishment of a spatial reference framework for a KiwiRail project site through to capture and delivery of spatial datasets in terms of that framework to the required specification to ensure quality and consistency. It recognises that all types of spatial data have value and therefore should be supplied to KiwiRail and sets out attribution and currency standards to ensure data quality is understood for future consumers of that information.

1.2 KEY CONCEPTS

This framework represents the introduction of some important new concepts pertaining to data attribution and spatial referencing of models on site:

1. Model Accuracy Standards: Recognising all spatial data has value to KiwiRail, but the spatial accuracy needs to be understood by future users of that data in a common language;
2. Model Currency: A simple way of classifying models at a point in time to indicate how up to date they are likely to be;
3. Survey Control Point Hierarchy: Specifications for physical survey marks on site to ensure connections between virtual models and the real world is maintained through the lifecycle of a project and through into asset management.

1.3 STANDARD REFERENCE

For dated references, only the edited cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

1.4 RELATED DOCUMENTS

It should be recognised that this framework forms part of a larger document suite, and may draw reference to other relevant standards, requirements, specifications, or guidelines included in Table 1.

Table 1: Digital Engineering 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.
Spatial Capture Framework	Outlines how spatial information is to be captured, created, referenced, 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)

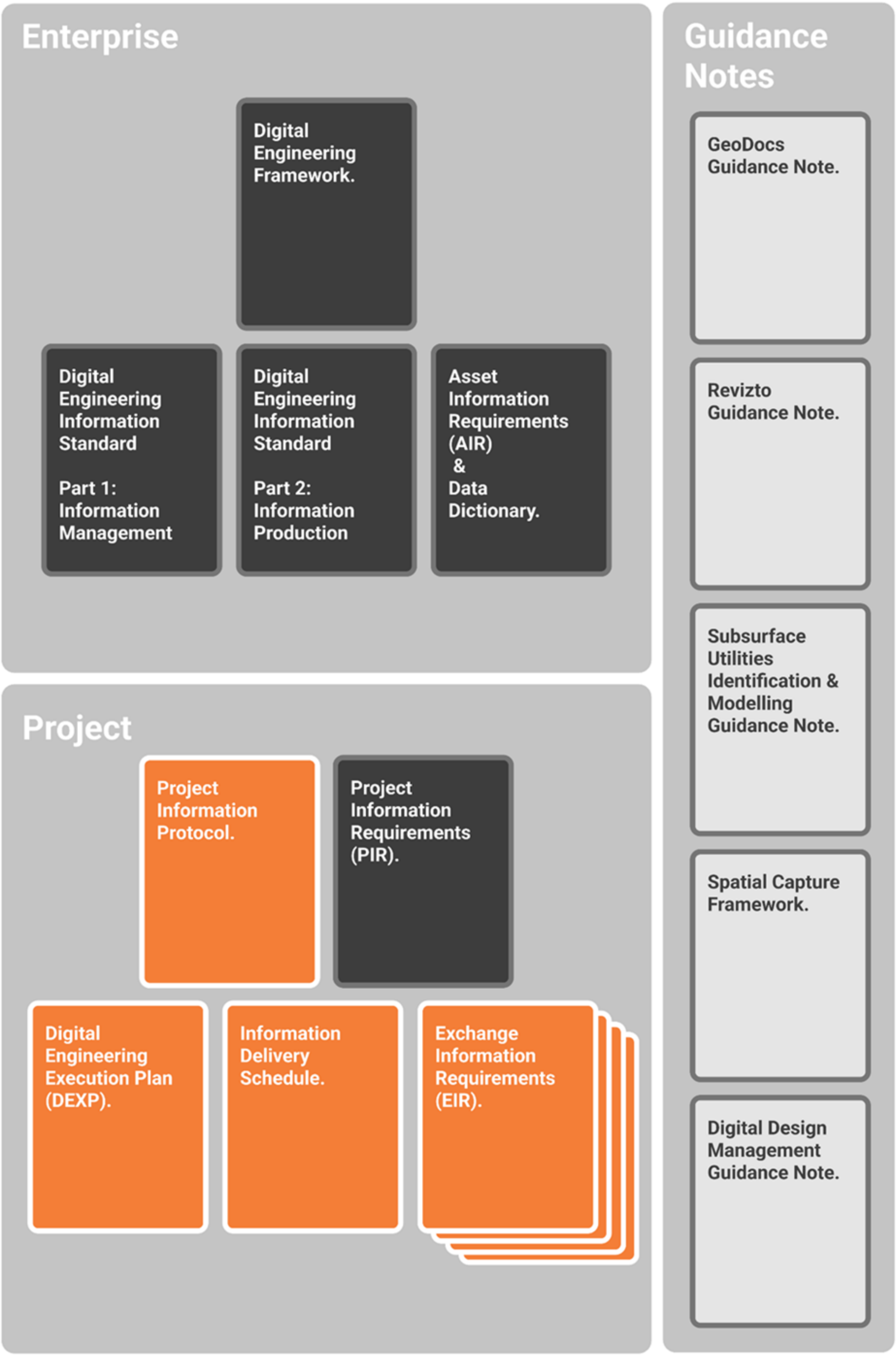

Figure 1: Digital Engineering Document Structure

1.5 TERMINOLOGY

The following terminology is used in this document, and the definitions below pertain to how these terms should be interpreted in the context of this framework:

Table 2: Terminology

Term	Definition
3D model	Any three-dimensional virtual model where the spatial dimensions are based on the international standard X Y and Z axes, and that reference frame is based on, or directly relatable to a KiwiRail approved coordinate datum.
As built	Refers to a 3D model virtual representation of any physical element or group of elements that exists in the real-world, captured by any measurement technique, and can refer to the existing state prior to a proposed modification or capture of the state following construction completion.
Coordinate datum	The framework that defines the spatial location of 3D models on the project site, consisting of coordinated physical control marks on site
Dataset	A set of digital information that includes a 3D Model or models, and associated data pertaining to that model
Laser Scanning	The process of capturing a 3D model of the existing environment with a large volume of discrete laser range measurements (sometimes referred to as LiDAR) combined to form a 3D virtual point cloud
MLS	Mobile Laser Scanning, a sub-set of Laser Scanning when captured by scanning from a moving marine or land based vehicle (including rail vehicle)
Greenfield site	Project site area (or part thereof) where with no existing rail infrastructure exists
Photogrammetry	The process of computing a 3D model from a series of overlapping photographs or continuous video capture of a specific site area or feature from multiple angles
Project Site	The physical extents of a specific project, including identified future project phases, and may be as small as a single facility site or as large as a full length of rail corridor.
Point Cloud	The derived 3D model from laser scan or photogrammetry where the model exists in digital form as a conglomeration of colourised 3 Dimensional points
Registration	The processing step where individually captured point cloud scans or photogrammetry model elements are merged into a model in terms of a project coordinate datum
RGB Colours	Colourisation of a model by photographic overlay colours (where any colour in the visual spectrum can be described by its Red, Green and Blue components)
Structure Gauging	Assessment of clearance between rail vehicles and surrounding infrastructure
Survey Control Point	Refers to any permanent or semi-permanent physical reference point on site, coordinated for the purposes of 3D data capture on that site
TLS	Terrestrial Laser Scanning, a sub-set of Laser Scanning when captured from discrete static locations (typically tripod mounted)
UAV	Unpiloted Aerial Vehicle, in the context where this aircraft is used as a platform for data capture equipment, either by laser scanning or photogrammetry

2 Accuracy Specifications

2.1 ACCURACY SPECIFICATION DEFINITIONS

These accuracy specifications defined by KiwiRail pertain to as-built models of the physical environment only (not design models). They have been formulated to ensure that the risks associated with reliability of any supplied as-built model is known in a standardised way, independent of current or future capture technologies.

- All accuracies are quoted at the 95% (2 standard deviation) statistical confidence level
- The levels can be applied differently to the horizontal and vertical components of a model for many project requirements:
    - Horizontal (denoted Hz) pertains both the X & Y planes combined, whilst Vertical (denoted V) pertains only to the Z plane
    - If a single Level is quoted it is assumed that both Horizontal (Hz) Vertical (V) must both comply to the same standard;

For the purposes of this document:

- **Relative Precision** is defined:
    - In general terms as the typical precision of the capture method used to define the form and spatial layout of features in the 3D model
    - In KiwiRail specific measurable terms as:
        - The repeatability accuracy of the measured position between 2 clearly definable features up to 20m apart captured from the same vantage point (either in the horizontal plane, the vertical plane or both); and if within the rail corridor must be met both parallel and perpendicular to the rail alignment
- **Repeatability Accuracy** is defined:
    - In general terms as the overall accuracy of an as-built model in terms of the project coordinate datum points
    - In KiwiRail specific measurable terms as:
        - The accuracy of any element in the model relative to the nearest two survey control point supplied with the model, if the position of that element were to be checked independently by a measurement methodology of equal or better accuracy
        - To comply with this level the accuracy, the coordination of the control point network itself must meet or exceed this level between adjacent points in the network
- Where the dataset is made up of discrete elements only with 3D locations in space (e.g. locations where photographs are taken, including 360 panoramas) the Repeatability Accuracy only shall apply, representing the accuracy of the discrete positional information associated with each data element.

2.2 ACCURACY LEVELS

Table 3: Quality Level Classifications

Level	Relative Precision (+/- mm @ 95% C.I.)	Repeatability Accuracy (+/- mm @ 95% C.I.)	Typical Application(s)
K0	4	6	Precise rail alignment surveys with survey control points within proximity
K1	8	12	Accurate 3D surveying applications (including 3D Laser Scanning for as-built infrastructure models), with good survey control point coverage on site
K2	12	20	Topography surveys and wider area laser scanning (including well executed MLS and some reality capture methods); a reasonable coverage of survey control points is likely required to ensure repeatable accuracy is achieved for the specific capture method
K3	25	40	Wider area laser scanning capture, topography, and site layout surveys (including accurate photogrammetry methods), often with less dense survey control point networks on site
K4	*50*	*100*	Wider area capture applications including some aerial capture methods, with limited ground control or reference points on or surrounding the site
K5	*100*	*250*	Models primarily captured for visualisation or context purposes but with spatial connection checked to survey nearby control points or points of reference in an existing site model
K6	*100*	*~1000*	*Measured model elements (e.g. using tape measure or photogrammetry) positioned in the model for context with some form of spatial referencing*
K7	*~100*	*~5000*	*Measured model element primarily for visual reference but spatial position in model is from low resolution GPS positioning (e.g. smartphone) or manual placement on map*
K8	*~250*	*~5000*	*Indicative shape form of an existing feature, placed approximately in model*
K9	*Unknown source and/or unverified spatial reliability*		

~ *denotes values that are indicative only*

A "higher" accuracy level refers to a level higher up in the table, not higher in numeric value in the name or definition

2.3 WHICH ACCURACY LEVEL SHOULD BE USED AND WHEN?

The accuracy level for a specific dataset requirement may or may not be specified by KiwiRail as part of the project brief. In instances where it is not explicitly stated, or this framework forms the only reference document, following guidelines shall be followed:

- For the as-built capture of a KiwiRail survey asset for general design purposes (including current and future project phases) the following default requirements should be followed and clearly stated to KiwiRail prior to commencement of capture:
  - K1 (Hz & V): Where critical infrastructure is being retained and tied into or engineered around (including Rail*, Overhead Electrification, bridges, tunnels, and buildings)
  - K2 (Hz & V): For existing built infrastructure present on site that may have impact on the project scope

    - K3 (Hz & V): Where the general topography and existing site state is required to be known for a project scope, but proposed designs do not tie in directly with existing features, or they are likely to be removed
- The following exceptions should be considered:
    - (*) Where the feature in the 3D as-built model is rail alignment (inside running edge) for the purposes of structure gauging, rail alignment redesign or tie in:
        - K1 (Hz & V) should be followed as the default specification; except
        - K0 should be considered where project site factors necessitate a higher degree of accuracy, in which case a rail shoe should be used for conventional survey pickup to verify the alignment and track feature positions in the 3D model
    - Where the dataset is captured purely for the purposes of concept design, optioneering or feasibility, and the future design is not certain or the cost of capturing to a higher specification is not considered cost effective, the following default specifications should be used (unless otherwise stated):
        - K4: for sites with existing general infrastructure impacting design
        - K5: for general project site topography models (including greenfield sites); this may include the use of publicly sourced Aerial LiDAR datasets
- Note also:
    - Where a subsurface utility is being captured in the as-built model, KiwiRail Subsurface Utility Identification and Modelling Guidance Note shall apply.
    - Levels K6 to K9 are to be used when the dataset is for information purposes only but has a spatial relationship to the project. KiwiRail advocates for all this information to be supplied for future reference, and the accuracy level is used primarily for the purposes of communicating the weighting any future user should be placing on the spatial integrity of that dataset.
    - Where the supplier of information has been asked by KiwiRail to supply information to an accuracy standard that they do not consider necessary, practical, or feasible they can seek approval from KiwiRail to relax the standard, stating the reasons why. Written approval must be granted by KiwiRail prior to commencing the data capture.
    - Where data is delivered to KiwiRail to a higher specification than the default or specified accuracy level, then no approval is required by KiwiRail if no additional cost is incurred by KiwiRail. If there are cost implications, but the supplier believes a higher specification is required then approval must be sought prior to commencing the capture task (including outlying reasons why a higher specification should be applied).

2.4 EVIDENCE REQUIRED OF SPECIFICATION MET

As part of the supporting information supplied to KiwiRail, evidence of the accuracy specification level achieved must be included in the survey report or supplier statement for all as-built models Level 5 or higher. This may include, but not limited to the following:

- **Relative Precision** achieved:
    - Manufactures Accuracy specifications for the equipment used
    - Equipment calibration results, including onsite checks at time of capture
    - Independent overlap checks in the model from different capture methods and/or epochs; examples include

        - Overlap residuals from the "stitching together" registration process between discrete elements that make up the dataset, summarised at the 95% confidence level
        - Redundancy and/or repetition of measurement under independent conditions, summarised at the 95% confidence level
        - Spot check measurements across different areas of the model by a higher accuracy method
    - Statement of compliance by suitably qualified survey professional based on their professional judgement
- **Repeatability Accuracy** achieved:
    - Manufacturer's accuracy specifications for the equipment used to control the overall spatial integrity of the model (including control point coordination);
    - Documented steps built into the capture methodology to minimise the risk of error propagation
    - Measurement redundancy built into the methodology, with residuals summarised at the 95% confidence level
    - Spot checks between control points and features in the model by a higher accuracy method
    - Metadata accuracy information from 3rd party datasets used
    - Statement of compliance by suitably qualified survey professional based on their professional judgement

IMPORTANT:

KiwiRail advocate for their contractors to supply as much information in 3D form as they can. Accuracy levels K6 to K9 have been defined for the purposes of assigning intelligence to the data for future reference and may be based on the judgement of the author of the data, therefore accuracy specifications are indicative only and do not require evidence of the specification being met.

3 Currency Levels

3.1 CURRENCY DEFINITION

"Currency" in the context of 3D spatial data for KiwiRail is an indicator of the likelihood that it still represents the current real-world state. The currency state is independent of the accuracy specification and is the highest at the time of data capture (for any data type). It could degrade for several reasons; the main ones being:

- Lapse of time since data was collected
- Known activity on site that has resulted in changes
- Other evidence to suggest the dataset may be "out of date"

Other important points to note:

- The better the currency level, the higher the chance the dataset has in representing the current state on site, however datasets with degraded currency levels still have value in terms of documenting historical site states
- By default all newly collected 3D models supplied to KiwiRail should be given the highest currency state, unless they are known to be out of date (e.g. historical datasets, pre-construction or site progress models supplied to KiwiRail after site changes have been made).
- This is a data attribute only and KiwiRail does not guarantee the currency of the model; it is the responsibility of the user of the data to confirm it is suitable for the purposes it is being used and validated on site if required.

3.2 CURRENCY LEVEL SPECIFICATIONS

Table 4: Currency Level Classifications

Currency Level	Name	Description
C1	Current Model	Model represented current state at time of delivery; there is no specific evidence to suggest it is out of date, but site observation should be considered to confirm currency depending on what the data is being used for.
C2	Aged Model	Time has lapsed since capture and the model may be out of date, or some other information suggests site changes have occurred on site; the model may still be suitable for some purposes however caution is advised including prudent site checks to determine if updated capture is required.
C3	Historical Model	Assumed or known to be out of date, and should be treated as a historical record only and would likely require recapture to update currency

4 Spatial Capture steps required for a Project Site

There are several steps that are important to consider when setting up the 3D capture of a project site to facilitate the KiwiRail Digital Engineering requirements seamlessly through the lifecycle of a project and beyond into management of the asset. These can be categorised into three key steps:

1. **Survey Control Network Establishment**

- Evaluate existing survey control on or around the project site
- Establish/upgrade new control point monumentation in accordance with KiwiRail Digital Engineering Requirements, if required
- Undertake survey measurements across the survey control network for the purposes of coordinating these control points to meet accuracy specifications for horizontal and vertical coordinates in terms of the site datum

2 Capture 3D Information Datasets

- Plan the capture methodology(ies) for providing datasets are that are fit for purpose for the project requirements
- Execute data capture in accordance with the Digital Engineering requirements

3 Publishing and Delivery of Models

- Ensure processing methodology has sufficient checks and balances to maintain model integrity
- Publish models to the required standard in terms of required digital format(s)
- Deliver via the KiwiRail digital portal along with required metadata and supporting documentation

KiwiRail's expectations for each of these steps are outlined in more detail in the sections below.

5 Survey Control Network Establishment

This is required for any project where an existing coordinate datum compliant with this standard has not already been established.

5.1 EVALUATION OF EXISTING SITE CONTROL

KiwiRail requires all models to be coordinated in terms of their standard datum(s), therefore existing site datums (and their associated coordinated control points) must be in terms of the following:

- Horizontal Coordinates must be in terms of NZGD2000 projection:
  - NZTM circuit; or
  - Local grid circuit when the project site is fully contained within a circuit's extents and KiwiRail's project plan states this as the horizontal coordinate projection being used
- Vertical levels in terms of NZVD2016

Existing site control is defined as any previously established survey control points in terms of the above datums on the project site in question, and/or the immediate surrounds. Whilst it is not a requirement to find the physical location and supporting coordinate information for ALL existing control points relating to a project area, there is a duty of care requirement to consider all potential coordinated points pertaining to that site and ensure connectivity to a coverage level appropriate for the extent of the site (including proximity in all directions).

These may include the following in hierarchy of importance:

1. Pre-existing KiwiRail published control points on or near site, coordinated by survey in terms of a KiwiRail standard datum to the required accuracy standard (and/or can be checked to confirm they meet the required standard)
2. LINZ Geodetic published marks of NZGD2000 order of 5 or better near the project site
3. Any other control mark known to exist on site for which might have been published as part of historical survey work even if the published coordinates for these points are not known (may be relevant for connecting, updating or verifying existing datasets)

The minimum requirement is for at least 3 existing control points of either type 1 or 2 above to found, connect to, and proved to be reliable since coordinated. However additional marks over and above this minimum should be searched for and included where practical in the following circumstances:

1. Those 3 marks are over a baseline length substantially shorter than the site capture requirement scale, or do not represent good geometry in terms of the capture area coverage
2. The site capture is for a site over 500m in length and therefore additional points should be included as the scale of the site increases

5.2 ESTABLISH NEW CONTROL

The Digital Engineering Process recognises a hierarchy of control points, up to three levels in the following order of importance:

5.2.1 Primary Survey Control Points

Purpose: Direct and unambiguous connectivity between virtual models of the site (including design models) and the physical site, coordinated according to the accuracy classification required for the detail design scope of a project (even if being established during earlier design stages).

Construction Type: Permanently established 3D survey control mark, including the following elements:

- Unambiguous centrally located point capable of precise coordination during current and future surveys

- clearly visible surrounding black and white symbol for the purposes of identification of central point by laser scanning and/or photogrammetry methods,
- Unique point ID permanently marked on or near the mark

The following are considered appropriate construction types:

- For project areas containing existing rail infrastructure (including buildings): A5 Sized black and white permanently installed signage to the standard in figure 2 below permanently attached to physical structures on site in readily visible locations
- On existing Paved surfaces a permanent survey nail or pin may be a more suitable alternative (including existing control points), with a surrounding white cross painted by stencil to a shape similar to that in figure 2 below, of a size appropriate for identification in photogrammetry capture methods

Coverage Requirements:

Where the dataset is being captured of existing infrastructure for the purposes of detail design:

- It is recommended that one primary mark should be visible with a 40m radius of the majority of locations where design integration is required (with a minimum of 4 points for small sites). Therefore the density will be site and scope dependant, but a density guide of 1 per 1000sqm could be used for most outdoor areas where design integration is required with existing built infrastructure.

Where the dataset is being captured for the purposes of general layout or concept design:

- Coverage should take into consideration the capture methodology being used, whilst considering the following:
    - a minimum of 4 points spread across the site area constructed to this standard, unless it is a greenfield site where no suitable locations exist at the early stage of the project;
    - coverage can also take into consideration future densification of primary control points during future site capture (including detail design stages), noting the accuracy standard of these control points should still be set according to future detail design requirements.

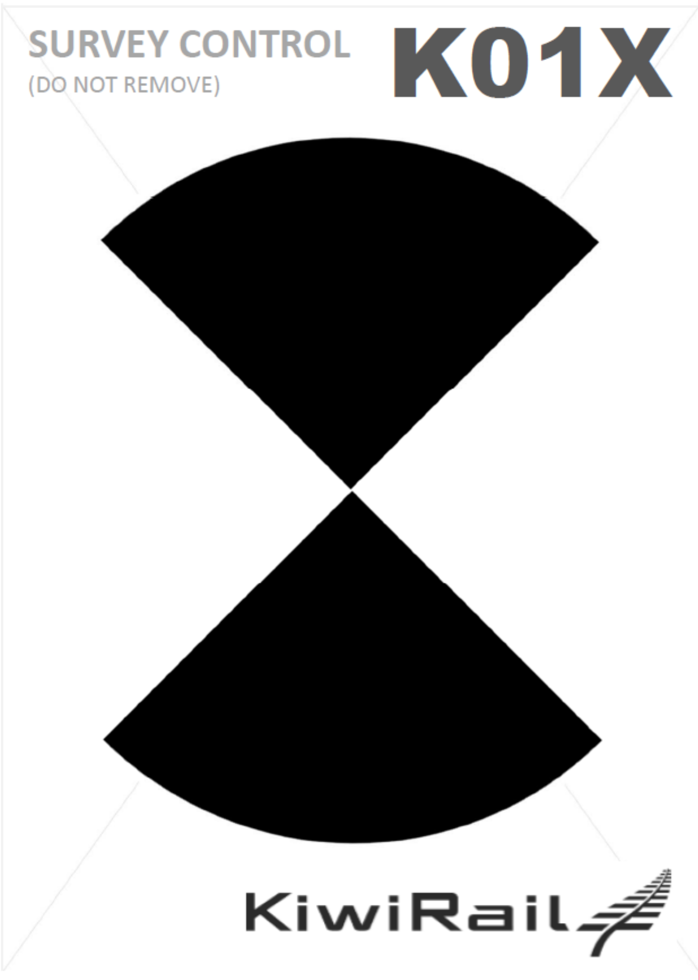

Figure 2: Typical KiwiRail Primary Survey Point Plate, A5 Sized, centred on surrounding plate

5.2.2 Secondary Survey Control Points

Purpose: Permanent conventional ground survey points (including existing control points) or wall mounted survey points used for the coordination or checking of Primary Control points, generally located to be suitable for setup of survey equipment over or survey resection, coordinated to the same accuracy as the Primary Control Points;

Construction Type: Typically, robust nail, steel pin, spigot, or survey plaques permanently installed flush in paved surface or shallow buried spike (witnessed by wooden stake if in grassed area). Note where spike is used consideration must be given to the KiwiRail permit to dig process.

Coverage Requirements: A minimum of 3 secondary points (inclusive of existing site control) are recommended on any site as witness marks for the coordination or re-establishment of Primary Control Points.

- Additional points may be required for the coordination of and/or checking of Primary Control points on larger sites.
- A lower number of secondary control points might be acceptable on project sites where survey control points have been upgraded to Primary Control points in terms of construction and appearance.

5.2.3 Tertiary Survey Control Points

Purpose: Survey points installed to a less permanent level and/or lower level of accuracy to the Primary and Secondary network, for the purposes of facilitating model capture at time of survey

Construction Type: At the surveyor's discretion, including but not limited to nails in paved surfaces, wooden pegs, marks made in hard surfaces, and temporarily placed scan targets used for coordination at time of laser scanning or photogrammetry capture

Coverage Requirements: At the surveyors discretion, dependant on survey methodology..

5.3 COORDINATION OF CONTROL POINTS

Coordination in 3 dimensions can be undertaken in parallel to 3D data capture but must have some key components:

5.3.1 Site Datum

A subset of the Existing Survey Points in the network, made up of 2 types of points:

- Origin Marks (primary source of existing horizontal and vertical coordinates for a site)
- Fixed marks in coordination adjustment (existing survey marks coordinates respected after being proved to be reliable)

5.3.2 Observations

Baselines between primary and secondary marks, coordinated by one or more of the following methods:

- GNSS baseline (static or RTK),
- total station observation,
- laser scanning target acquisition,
- precise levelling
- Other measurement methods appropriate to meet accuracy requirements (including tape measurements, line, and offset observations)

The coordination of any point in the network must be based on the principle of observation redundancy, with a degree of independence in these observations. Put simply, if an error is present in an observation (either gross or systematic error) then one or more independent observations should have a high chance of detecting this error.

5.3.3 Adjustment & Reporting

The coordinate adjustment must be based on software that uses Least Squares Adjustment of observations, with the key components:

- All validated observations should be included in the network adjustment, with weighting appropriate to the observation type
- Observation residuals should be consistent with the expected observation error, based on a normal distribution of error propagation
- Observations rejected from the adjustment only where there is clear evidence of gross error
- Minimally constrained network results must be used initially to validate observation integrity within the network, and reliability of existing mark coordinates prior to fixing of origin marks
- Final adjusted coordinates and a posteriori errors should be reported at the 95% confidence level.

The results of the above process must be included in a survey report supplied with the control survey as evidence of the standards met.

6 Capture of Spatial Datasets

This part of the framework is applicable to all spatial capture of information for a project site.

6.1 PLAN THE CAPTURE METHODOLOGY

The site survey data capture methodology or methodologies deployed for a site should be considered based on the following factors prior to undertaking 3D capture of an existing site state:

1. Safety of the personnel involved in the capture as well as other affected parties (including other KiwiRail personnel and members of the public)
2. Supporting the principles of KiwiRail “Model First” design principles
3. The accuracy level required to be achieved for the project scope
4. Efficiency of capture and cost implications ensuring the value is not disproportional to the design objectives of the project
5. Site specific parameters including scale of the area, accessibility and other factors that may necessitate alternate of a combination of capture approaches

KiwiRail may recommend capture methodology but suppliers of survey information to KiwiRail may choose the method based on meeting the above requirements, provided it is endorsed by the relevant KiwiRail project leader prior to that capture being undertaken.

6.2 EXECUTE DATA CAPTURE

Site capture will be specific to the project requirements, however, should ensure the following guidelines are followed:

- The factors listed in Section 6.1 above are adhered to
- Connectivity to the site control point network is robust (whether it has been installed independently to the main data capture phase, or concurrently) so that the repeatability accuracy standards can be validated by an independent party
- Shadow areas in the capture model are minimised, noting that some areas of the site may be preidentified as having lower impact on informing the design objectives of the project
- Visual integrity of the captured model is maintained, including making every practical effort to capture imagery in reasonable daylight or artificially enhanced lighting conditions to achieved RGB coloured models (including photogrammetry and laser scanning methods).

7 Processing and Delivery of 3D Models

7.1 MERGE AND VALIDATE DATA MODELS

Ensure processing methodology has sufficient checks and balances to maintain model integrity during the data merging or registration process, including reporting of the accuracy of the results achieved. Examples of the minimum standard expected for different scenarios are outlined in the table below:

Table 5: Methodology Guidelines for Model Processing and Validation

Survey Capture Method	Minimum Standard Guideline
Terrestrial Laser Scan	Scan to Scan registration is only used in situations where there is good overlap of hard surfaces between adjacent scans, and in these cases not relied upon at the sole registration constraint. Survey scan targets should be coordinated (during capture or post processed) in each scan, including for construction of the Primary, Secondary or Tertiary control network. Overlap constraints (either scan targets and/or scan to scan alignment) should minimise distortion risk by having good coverage and geometry relative to the area scanned. Registration residuals should be reported as part of the evidence that the accuracy standards have been achieved (both relative and repeatability standards). Colour imagery shall be captured and applied as RGB point cloud colouration in the model, therefore reasonable lighting conditions should be maintained during the capture process.
Mobile Laser Scans	For K3 standard or better multiple drive passes should be captured, and drive pass matching carried out and reported on during processing; For K2 standard or better at least 4 independent passes should be captured (it is recommended that 3 in each direction should be targeted for observational redundancy). Areas of limited sky visibility (including zero sky visibility environments) there should be additional feature coordinate constraints in the registration process sufficient to prove that the accuracy specification has been met. Colour imagery shall be captured and applied as RGB point cloud colouration in the model, therefore reasonable lighting conditions should be targeted.
Photogrammetry Methods	The rigour of the capture and processing methodology must be consistent with the accuracy specification level required. For K4 standard or better error residual values for model control points must be supplied. For K3 standard or better the error residuals for independently surveyed points or features in the model between the ground control points used in the model registration must be supplied as supporting evidence that the repeatability accuracy standard has been met. These check points should include features both at ground level and above ground level to mitigate the risk of distortions across the model. These checks can be either 3D points, or horizontal and vertical check points provided separately.

8 Information Delivery

All spatial data and information shall be delivered to KiwiRail via the KiwiRail Common Data Environment. For details on accepted file formats, and other technical requirements refer to the KiwiRail Digital Engineering Framework, including Information Standard Parts 1 & 2.