

Letter of instruction

Information for users

The following document:

NR/L3/TRK/3101 Issue 1

has had changes made to it, most recently, with effect from **5 November 2015**.

Instructions for use

It is essential that you first read and understand each letter of instruction pertaining to the standard before proceeding to use the standard. You must then apply the requirements of each letter to the standard.

NR/BS/LI/354	Issue 1	5 November 2015	Proceed to letter ►
NR/L3/TRK/3101	Issue 1	4 September 2010	Proceed to standard ►

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Level 3

Topographic, engineering, land and measured building surveying – Track

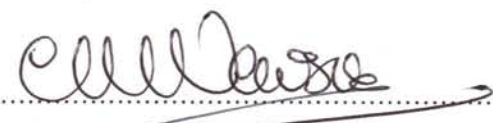
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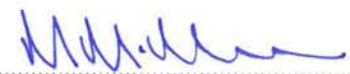
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Issue record

Issue	Date	Comments
1	September 2010	First issue.

Compliance

This Network Rail standard is mandatory and shall be complied with by Network Rail and its contractors if applicable from 4 December 2010.

When this standard is implemented, it is permissible for all projects that have formally completed GRIP Stage 4 to continue to comply with the Issue of any relevant Network Rail Standards current when GRIP Stage 4 was reached and not to comply with requirements contained herein, unless the designated Standard Owner has stipulated otherwise in the accompanying Briefing Note.

Reference documentation

GE/RT8000, *Rule Book*.

NR/GN/CIV/008, *Model Clauses for specification of Civil Engineering Works*.

NR/L2/TRK/2102, *Design and construction of track*.

NR/L2/TRK/3100, *Topographic, Engineering, Land and Measured building surveying – Strategy and general*.

EDM calibration. RICS Guidance Notes series. 2nd Edition. December 2007. RICS.

GRD007. *Precision site survey (topographical survey) for the production of level crossing ground plans*. Issue 1.

Guidelines for the use of GNSS in Surveying and Mapping. RICS Guidance Notes series. 2nd edition. 2010.

Need for calibration – Reassuringly Accurate. RICS Guidance Notes series.

PWI Book S&C Maintenance. Volume 5.

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1 Purpose

This standard facilitates the creation of a specification for Topographic survey works. It provides guidance to Project managers and Designated project engineers on specifying and commissioning Topographic surveys where the accuracy needs are better than $\pm 100\text{mm}$ in position). It is intended to be used with NR/L2/TRK/3100, *Topographic, Engineering, Land and Measured building surveying – Strategy and general*.

Guidance on the various techniques most appropriate for the GRIP stages are found in the NR/GN/TRK/3103, *Survey and mapping techniques*.

2 Scope

This Network Rail standard specifies requirements for surveys of track, platform extensions, level crossings, utilities, gauging and implementation of S&C for which a co-ordinated Engineering, or Topographic survey is required.

Requirements for individual project scopes are specified in the appendices to this standard, as illustrated in Figure 1. The appropriate parts of this standard are intended to be used with NR/GN/TRK/3103 to identify the relevant survey methodology appropriate to the GRIP stage.

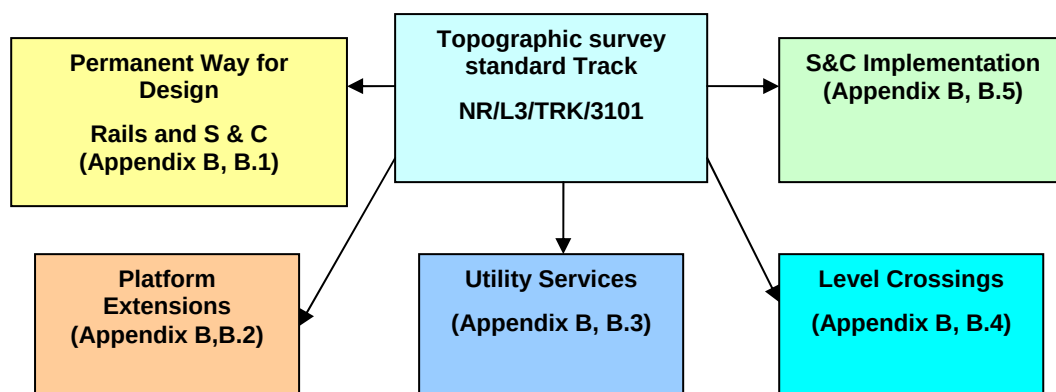


Figure 1 – Project scopes and appendices

NOTE As an example, consider a track renewal site. In general terms, a decision has to be made between the options of a Hallade survey (5.11) or Total Station (electronic theodolite and EDM) planimetric survey (5.7). All planned works in the area should be considered (track and other disciplines). The Project life span is often longer than the typical "shelf-life" of a track survey (six months maximum). The survey should be completed so that it can be easily updated, as required by the works, or to reflect changes in track position (alignment validation, 5.8).

Types of track survey and where to find the processes are given in Figure 2.

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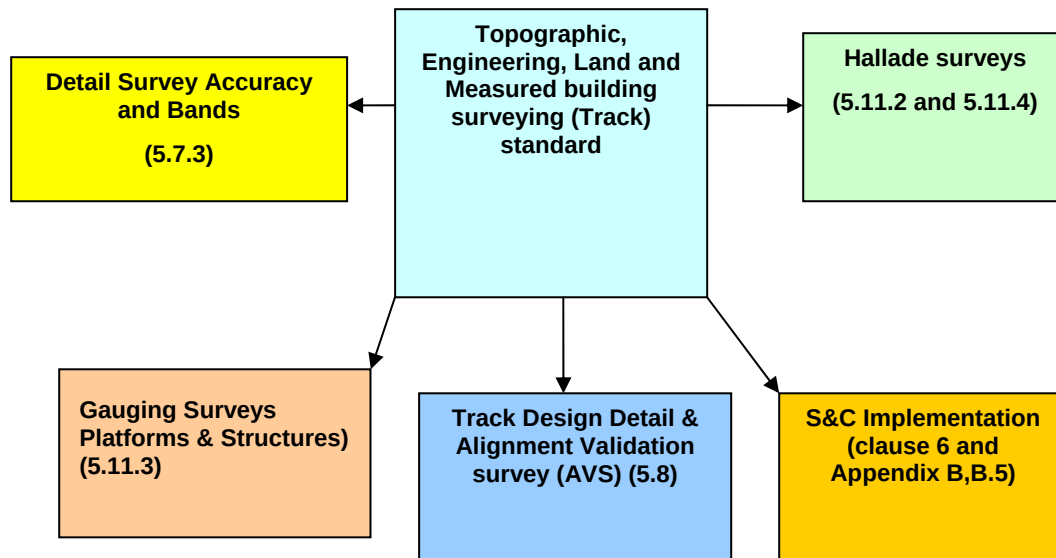


Figure 2 – Survey processes for track survey types

3 Definitions

For the purposes of this standard, the terms and definitions given in NR/L2/TRK/3100 apply.

4 Survey process

4.1 General

A Project Survey strategy shall be created by the Project Manager with assistance from the CSM prior to the commencement of work as specified in NR/L2/TRK/3100, **5.1**.

NOTE Not all parts are applicable for all projects. Figure 3 identifies the salient parts of this strategy.

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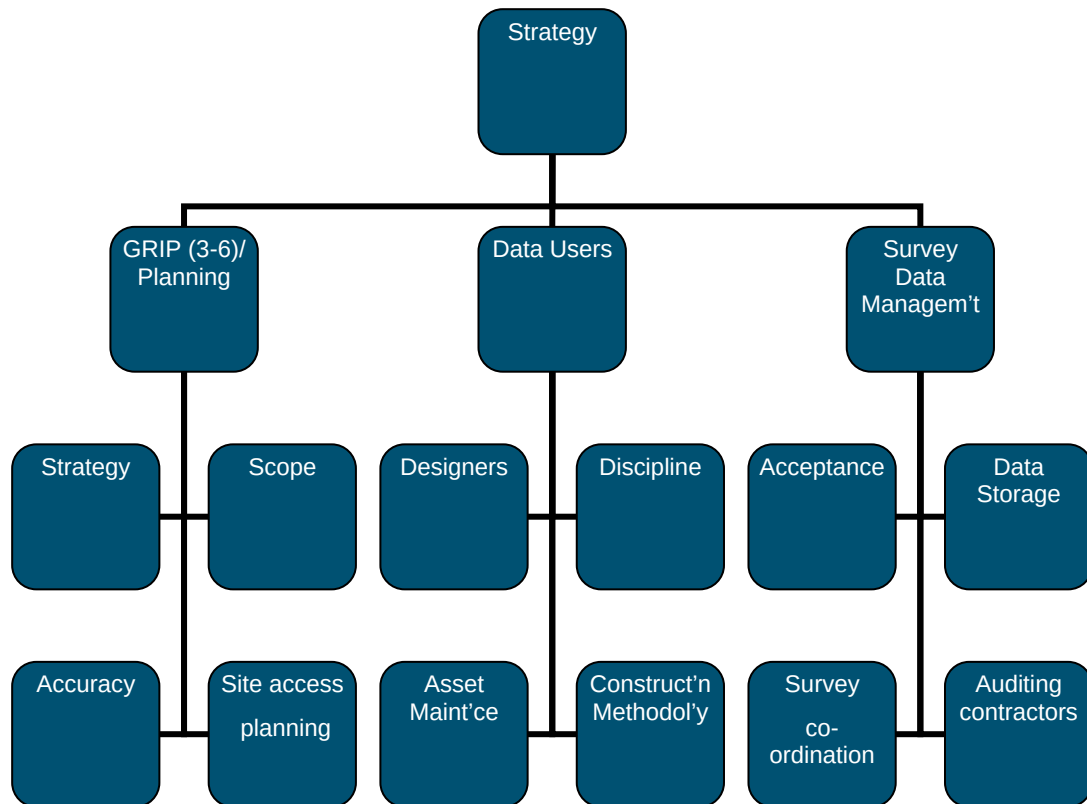


Figure 3 – Project survey strategy

4.2 Survey grids

4.2.1 General

To achieve integration of all survey and asset information data of various types, a project policy on survey grids shall be established at the outset. The project policy shall embrace the use of a design longitudinal chainage or metrage.

NOTE 1 This avoids confusion with ELR miles and chains.

NOTE 2 The project grid is important as it enables the curved earth to be mathematically defined as a plane. A number of variations may be appropriate. The best variation to use is dependant on the nature of the project and what other pre-existing infrastructure it is required to interface with.

The Project Manager or Designated project engineer shall consult with the CSM to choose from the following:

- Ordnance Survey national grid (OSGB36);
- bespoke design of Absolute project grid (APG), e.g. Snakegrid such as WCG05 (see NR/L2/TRK/3100, **8.2.3**);
- utilise a pre-existing survey grid (e.g. the London Survey grid (LSG));
- Local project grid (LPG).

*NOTE 3 Full descriptions and consideration of the advantages of each type are specified in NR/L2/TRK/3100, Topographic, Engineering, Land and Measured building surveying – Strategy and General, **8**.*

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The survey grid shall be defined on the ground by a network of permanent ground markers (PGMs).

NOTE 2 These are usually based on a hierarchy of Primary, Secondary or Tertiary PGMs.

4.2.2 Longitudinal metreage

At the project outset, a unique location shall be defined as the origin of the running design chainage/metreage. For a track related project, a certain rail or the centre line of the down main shall be used as the reference metreage. This shall be made to coincide with a clearly defined location on the ground that is unlikely to change, such as the start of a tunnel, bridge, other structure.

NOTE 1 Mileposts are often destroyed or physically moved during track renewals work, so they are not particularly suitable.

NOTE 2 The longitudinal design metreage does not have to start at 0 m and is usually set to be 1000 m or similar.

NOTE 3 For example, on the West Coast project the North Portal of Primrose Hill tunnel was defined as the start chainage and a value given to this. The chainage ran along the centre line of the down main.

NOTE 4 Although initially this metreage (or "Master" chainage) may run along an existing feature the points are co-ordinated and thereby provide a theoretical line. During the project the original feature may be moved but that does not alter the theoretical master metreage that may still be applied to any line, approximately parallel to the original.

4.3 Permanent ground markers (PGMs)

4.3.1 Location and design of permanent ground markers

The location and design of permanent ground markers shall be as specified in NR/L2/TRK/3100, **8.3.1**.

4.4 Deliverables

4.4.1 PGM witness diagram

A PGM witness diagram shall be produced for each PGM when not located on OLE/signal base. It shall show its general location with dimensions to at least three easily recognisable and durable points.

These shall use NR/L2/TRK/3100/Witness diagram 01.

4.4.2 Other deliverables

A schedule, schematic or true to scale (TTS) plan in Microstation *.dgn format and a Survey report shall be prepared as specified in NR/L2/TRK/3100.

5 Engineering and topographical

5.1 General

Survey grids shall be as specified in NR/L2/TRK/3100.

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NOTE 1 Guidance on GNSS Control surveys is provided in NR/GN/TRK/3103.

NOTE 2 It is assumed that at least Secondary PGMs have already been established.

5.2 Tertiary control

NOTE 1 Although GNSS techniques may be used under some limited circumstances, it is expected that a total station traversing network will be used for tertiary or infill control between the first or second order PGMs.

In all cases, the first and second order PGMs shall remain fixed in the survey calculations.

When trackside infill PGMs are required between the secondary PGMs, they shall be established at a maximum of 200 m intervals.

NOTE 2 When PGMs are being used during possessions, significant problems arise where the PGMs locations alternate, from one side of track to the other and it is not possible to access one side due to only one road being under possession. Consequently, it is a practical consideration, when TMGs are not planned to be installed, to install a pair of trackside PGMs, one on each side, offset by 50 m, rather than one every 200 m.

5.3 Traversing

Traverses shall start and finish on a pair of known PGMs.

Open traverses, starting on a PGM but not closing on one, shall not be used.

Fly stations shall only be used to enable measurement of small areas of low accuracy detail, e.g. at the bottom of a bank or area where an obstruction occurs.

NOTE 1 A fly station is a single leg off the main traverse.

The following information shall be recorded on the total station for each pointing:

- horizontal angle (HA);
- vertical angle (VA);
- slope distance (SDi);
- instrument height (HI);
- target height (HT).

The HI and HT shall be measured to an accuracy of +/- 2 mm.

At each total station set up, a series of pointings shall be made to a backsight PGM, any intermediate PGM and a foresight PGM. The telescope shall be transited and the pointings re-read, in reverse order this time.

NOTE 2 This process is known as a round.

Modern total stations using automatic target recognition (ATR) shall be set to undertake such repeated measurements automatically.

These readings shall be logged digitally or, in exceptional circumstances, recorded in ink on a suitable field booking sheet or field book.

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Each PGM shall be occupied in turn, two or more rounds of angles shall be undertaken with different Reference Object (RO) values and distances will also be observed.

NOTE 3 Distances might only be possible on a single face.

The instrument shall then swap places with one of the targets and the process repeated.

NOTE 4 This process is known as "leap frog" traversing.

If the means of the rounds of angles differ by more than 5" of arc, another round shall be carried out until an acceptable spread is achieved.

Upon reaching the final PGM in the traverse, a calculation shall be made of the co-ordinates. A closure vector shall be calculated. This shall be done by the survey contractor before leaving site. The closure error shall be better than 1/50,000 (20 mm per km).

If the closure does not conform, the observations shall be repeated in part or whole, until a suitable closure is achieved. If this not be possible, the results shall be sent to the Client's Survey Manager for consideration.

NOTE 5 Where possible, the control traversing should be established simultaneously with any detail track design survey, and the TMG reference point survey (if required).

When it is not possible to close out the traverse between second order PGMs within one working shift, the last station (at the end of a working shift) shall be referenced. This shall be undertaken by observing three full rounds of angles to include the back station, fore station and one lateral reference point. Distances to the adjacent stations shall be observed using free standing prisms (not hand-held).

Upon resumption of the survey, the last station shall be reoccupied and the angles and distances checked for disturbance of the infill control point. Once this has been verified, the survey may be resumed.

5.4 Tertiary and infill control levels

These PGMs shall be double-levelled within a level run opening and closing on a previously established primary or secondary PGM (or a combination of both). Each infill PGM shall be a change point. The levelled point shall be the top of the PGM nail.

5.5 TMG survey

TMG surveys shall be co-ordinated by bearing and distance observed from a minimum of two tertiary or infill PGMs. If any TMG is not visible from the infill PGMs, this control shall be extended by conventionally closed traversing. Open traversing shall not be used.

It might be possible to incorporate the TMGs as part of the infill control traversing depending upon the location and construction of the supporting structures. The published co-ordinates and levels of the TMGs shall be the prism centre.

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5.6 TMG point levels

The TMGs shall be installed level.

The TMG shall be:

- a) spirit-levelled simultaneously with the infill control levelling operation; or
- b) double “trig. heighting” of the prism centre (vertical angle and distance) shall be performed and accepted where the two derived values agree to within 5 mm overall. Mean values may be accepted.

NOTE The levelled point may be the top or bottom of the spigot and a value of 6 mm will need to be subtracted (top) or deleted (bottom) from the levelled value to get to the level of the centre of the TMG.

5.7 Planimetric Information

5.7.1 General

The planimetric information shall be surveyed according to the requirements as specified in Appendix B.

5.7.2 Height information

Height information shall be provided as spot heights throughout the survey area in a nominal 20 m grid. Sufficient levels shall be surveyed such that the ground configuration, including all discontinuities and key features are fully captured by the digital ground model.

5.7.3 Accuracy – guidance

This is a complex subject and only the briefest of explanation is given here.

Accuracy is defined statistically as the root mean square error (rmse) or maximum tolerance. The rmse is equivalent to 67% tolerance and 90% tolerance is 1.65 times the rmse when a representative sample of points is tested. Thus, an rmse of ± 5 mm (band 1 Accuracy below) indicates that when a representative sample of 100 points is tested not less than 67 shall be better than ± 5 mm and not less than 90 points shall be correct to better than ± 8 mm. Any errors exceeding three times the rmse, in this case ± 15 mm may be regarded as mistakes.

Accuracy has been considered in relation to “Bands”. The higher the Band, the more accurate the survey is. However, where a survey has been created for one user and another user wishes to utilise the same survey for an alternative purpose the new user needs to satisfy themselves that the survey is “fit for their purpose” by undertaking some validation of the data.

NOTE See NR/L2/TRK/3100, clause 12.

It is not desirable to have a single accuracy band as increasing the accuracy usually results in greater time and costs for data capture.

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By way of further explanation on the application of accuracy, surveying accuracy is a complex relationship between a number of different potential sources of random errors comprising the “Survey system”. Each part of the system may have an accuracy or “standard error” associated with it and as combination the following formula applies where suffix *m* is resultant standard error and suffices 1 to 3 are individual errors:

$$\sigma_m = (\sigma_1^2 + \sigma_2^2 + \sigma_3^2) \quad (1)$$

EXAMPLE

Consider the scenario when a point is to be set-out or marked out on the ground from a PGM.

PGM installation accuracy of ±5 mm in relation to the survey grid.

Accuracy of setting up over PGM or centring error ±1.5 mm

Total station accuracy of 1” Angular accuracy and 3 mm ±2 part per million of distance.

Target accuracy ±3 mm

Point to be set out is 50 m away.

Therefore using equation (1), the final accuracy of point set-out is ±6 mm in relation to the PGM or in relation to another point set-out from same location ±12 mm.

Band	Vertical mm	Horizontal mm
Band 1	±5	±5
Band 2	±10	±10
Band 3	±25	±25
Band 4	±50	±100

Table 1 – Survey accuracy bands

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Discipline	Type of work	Accuracy Band
Civil	Platform surfacing	1
	Coping	1
	Tunnel walls	1
	Steelwork	2
	Foundation	2
	Brickwork/blockwork	2
	Earthworks	3
	Troughing	3
Pway	Plain line alignment	1
	S&C alignment	1
	Datum plates	1
	Within structure gauge	1
	Drainage	2
	Formation	3
	Sand or bottom ballast	3
OLE	Steelwork	1
	Wiring, incl. Height & Staggers	1
	Foundations	2
Signals	Ironwork	1
	Positioning	3
	Sighting	4

Table 2 – Discipline accuracy bands

Band number should be referred to when accuracy is discussed.

This example shows the effect of effect of combining survey tolerance and setting out tolerance (construction tolerance).

NOTE NR/L2/TRK/2102, Table A.1 specifies values in relation to variation from design.

NOTE Accuracy Band 1 at ± 5 mm is worse case scenario between adjacent observed points but in practice the relative accuracy between points 10 m apart when measured with a properly adjusted and calibrated total station would conform to the requirements specified in NR/L2/TRK/2102, Table A.1.

NOTE Where different accuracy surveying techniques have been used for various features within a survey, Table 2 should be added to any drawing title box to reflect this and referred to in any "metadata" associated with the survey model file.

5.8 Detail and track alignment validation survey (AVS)

5.8.1 General

Details of the extent of survey shall be provided by the Project Manager or Designated project engineer with assistance from the CSM, within the tender contract documentation, defined by a marked up plan with ELR, and with start and finish mileage and lines needed highlighted.

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The survey contractors shall use Method 1 (5.8.2) or Method 2 (5.8.3) for all detail and alignment validation survey work, related to permanent way including Through Alignment and overhead line equipment (OLE). When a “refresh” survey is required, Method 3 (5.8.4) shall be utilised.

NOTE Other methods, such as the use of GNSS for accuracy bands 3 and 4, using accepted good practice as defined in Guidelines for the Use of GNSS in Surveying and Mapping, 2nd edition 2010, published by RICS, may be used for more general, less accurate, detailing applications.

5.8.2 Method 1

5.8.2.1 General

Detailing and AVS shall be completed either using total station radial methods or tape and offset methods, or a combination of the two.

The prism constant for the instrument/prism combination shall be known by the total station operator and the value inserted in the appropriate place in the instrument display or, if this is not known, reference shall be made to instrument manual or contact the instrument manufacturer or failing this arrange for the prism constant to be calculated, using approved techniques.

The instrument set up PGM shall be checked for relative accuracy with a minimum of two adjacent PGMs, prior to use. Differences greater than 15 mm in either X, Y or Z shall be notified to the CSM.

5.8.2.2 Total station radial method

At each station set up, the surveying instrument shall be centred and levelled correctly over the PGM or positioned using free-station observations on at least four TMG points.

The instrument shall be pointed at the Reference Object (RO) and a value set on the surveying instrument.

NOTE 1 This may be set to 0° or another suitable value.

Where free stationing has been used, a point with a distance of greater than 400 m shall be used for the RO.

A reading of HA, VA and SDi shall be observed to the RO, having also measured the height of the instrument and RO above the PGM to an accuracy of ± 2 mm. This shall be logged on the instrument or data logger, or written in ink on a field sheet or book.

If PGM co-ordinates have been previously published, these shall be checked.

Where free stationing has been used, the calculation residuals shall be reviewed. Any outside of 6 mm shall be rejected.

A report shall be generated and sent to the CSM indicating where this has occurred to allow remedial action on the published values to be undertaken.

Observations of ground points may now commence. The distance to radial points shall not exceed 100 m (120 m for overlap track points only).

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When working on railway sites, the detail pole used shall be non-conductive or insulated. The height of the prism for a rail foot shall be accurately measured and shall not exceed 200 mm above rail level. The rail foot shall also have a spirit level associated with it so that it is held in the correct plane.

After between 50 or 60 observations, or if the bubble has moved two or more graduations from level on the plate bubble, or the electronic bubble indicates movement, the RO reading shall be checked and the value recorded and compared with the previous reading. If a difference of greater than five seconds of arc is noted, the surveying instrument shall be re-levelled (if necessary) and a new RO reading recorded.

The RO reading shall also be checked after the passage of a train on any of the immediately adjacent tracks.

At the end of the set up, prior to dismantling the instrument a final RO reading shall be observed, recorded and compared with the most recent value.

NOTE 2 Check here for gross errors of angle, which might mean checking back through the observed data to find where the change has occurred.

Fly stations may be used for detailing into awkward areas. In this case, no more than two shall be created from a single set up. In such circumstances, common radials shall be observed and compared.

Null levels for string points shall not be created unless there is no other alternative or unless there is a special requirement in the specification.

Where bank slopes are to be surveyed, strings shall run along the bank rather than up and down the bank slope.

NOTE 3 This will enable the production of meaningful cross-sections.

5.8.2.3 Alignment validation/track detail survey

Total station radial observations shall be made to the running edge of both rails at a defined longitudinal interval that shall be marked up on the track. Acceptable spacings shall be as specified in Appendix B, **Table B.1**. For track observations, a minimum of three points of common overlap shall be recorded for each adjacent instrument set up.

The positions of insulated block joints (IBJ) joints, rail joints, welds and other features such as undertrack crossings (UTX) or any infrastructure feature that would require disconnection or removal to enable track works shall also be co-ordinated.

The position of the black "+" on the datum plates shall also be co-ordinated where the Absolute track geometry (ATG) concept is being used.

NOTE 1 This is signified by a green block on the datum plate that is always at the top of its possible adjustment.

In non-ATG areas, the top of the red block defining the level and the face of the datum plate (where track name is given) shall also be co-ordinated.

NOTE 2 This defines the place where the track offset is measured to.

The distance from the instrument to any point of detail shall not exceed 100 m (120 m for overlap track points only).

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The prism shall be fixed at the bottom of the detail pole with a “rail foot” thereby enabling the rail running edge, at 14 mm below the head of the rail, to be accurately co-ordinated as well as the level of the head of the rail.

NOTE 3 We thank a number of suppliers for permission to use the attached pictures.

Error! Objects cannot be created from editing field codes.

Figure 4 – Rail foot example 1



Figure 5 – Rail foot example 2

5.8.3 Method 2

NOTE 1 Instead of using a rail foot to survey the track position, the track may be surveyed utilising a track measuring device (TMD). Simple devices incorporating a cant stick and rail gauge measurement along with the prism may be used if the geometry between the prism and the reference rail is known.

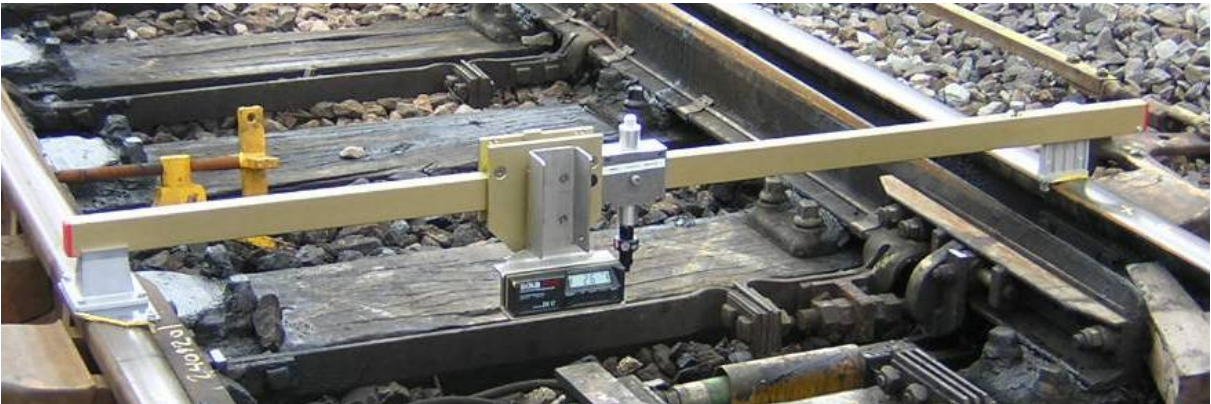


Figure 6 – Cant and gauge measuring device