Toitu te Land whenua Information New Zealand

LANDONLINE PRE-VALIDATION

ACCURACY RULE TESTS RUN DURING PRE-VALIDATION OF CADASTRAL SURVEY DATASETS

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Version 4.0

Land Information New Zealand
Customer Services

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Introduction

Purpose

This document provides information about the accuracy-related business rule tests that are run as part of the Cadastral Survey Dataset (CSD) pre-validation process. The business rule tests are designed to ensure that the CSD complies with the Rules for Cadastral Survey 2010. The results of these tests are found in the section of the pre-validation report headed "Adjustment Report".

There are two key aspects to creating an accurate CSD:

1) Survey Design
2) Survey Implementation

Landonline tests these two aspects of a CSD separately. This section describes the difference between design and implementation and how Landonline tests both during *e-survey* pre-validation.

Survey design

A survey must be well-designed. The two main factors contributing to the design are:

1) Geometry; and
2) Observation accuracy.

Geometry includes the distribution of marks in the survey and the observations between the marks.

Observation accuracy is assessed as the expected accuracy. That is, the observation accuracy that is typically expected given the equipment and observation procedure used.

Good survey design comes from making appropriate choices for equipment, observation procedure, new mark location and existing mark connections.

An accurate survey will have a design that leads to marks being accurately positioned.

Survey implementation

A survey must be well-implemented. The main factor contributing to this is the size of the actual errors in the survey.

Any given survey design is implemented by making observations (measurements) in the field. The quality of the implementation can be assessed by examining the observation miscloses (residuals).

An accurate survey will have small observation miscloses.

For examples of the difference between design and implementation, see Appendix A: Design vs Implementation Examples on page 58.

Contents

This document covers the following:

1) Description of the accuracy-related business rule tests
2) Details of how Landonline determines accuracy of observations
3) The importance of correct data capture for the running of business rule tests
4) Adjustment error and warning messages
5) Why business rule tests fail
6) Why business rule tests are sometimes not carried out
7) Why business rule tests sometimes pass, even though the CSD contains non-compliant data, including details of how such CSDs may be identified
8) Concepts of survey accuracy and how these relate to pre-validation

Other documentation

This document deals only with the "Adjustment Report" section of the pre-validation report. For information about other aspects of the pre-validation report see "Landonline Pre-validation Report Explanation" available on the Landonline website.

Audience

This material is aimed at surveyors and their staff who carry out *e-survey* capture. It is also aimed at providers of *e-survey* bureau services.

It assumes the reader is familiar with Landonline and *e-survey* plan capture.

Version 4.0

Version 4.0 is a review that updates the document to reflect the Cadastral Rules for Survey 2010 and the consequential changes made to Landonline.

Examples that demonstrate the tests and their outputs have not been updated as they were obtained from actual pre validation reports prior to the implementation of the Rules for Cadastral Survey 2010. Accordingly, rule references will not match pre-validation reports that are generated after 24 May 2010.

Part 1: Survey Accuracy and Business Rule Tests

1.1 Overview

Purpose

During pre-validation, Landonline runs four business rule tests to check that the CSD is compliant with the Rules for Cadastral Survey 2010 concerning survey accuracy.

This part of the document describes the accuracy tests that run during the pre-validation of CSDs. It describes why the various tests are run and what each test is actually checking.

Part 1 also discusses the information required to ensure that the tests give reliable results.

Business rule tests

Survey design and implementation are tested against several business rules. These tests are the same for both external survey pre-validation and LINZ internal survey validation, and are summarised in the following table:

Any CSD scheduled for a C184/C185 test will only be tested against one of these. If the CSD is connected to a least one Survey Accurate Digital Cadastre (SDC) mark, then the C184 test runs. Otherwise, the C185 test runs

Business Rule	Description	Aspect Tested	S-G Rule(s)
C468	C468The distances between boundary marks and their closest witness mark comply with the Rule for Cadastral Survey 2010.	Design	7.3.2(a) 7.4.3(c)
C485–	C485 Every PRM is within the applicable horizontal distance specified of a boundary point that is required to be witnessed by Rule 7.3.1	Design	7.4.2(a)
C440	Horizontal Datum connection	Design	4.2
C182	C174 Survey internally consistent (Internal Consistency Adjustment).	Design and Implementation	3.1 3.3.1. 3.6
C184	C119 Survey consistent with SDC network specified tolerances (Full/Partial SDC Adjustment).	Implementation	3.1 3.3.1 3.6
C185	C119 Survey consistent with Non SDC network (Underlying Survey Adjustment).	Implementation	3.1 3.3.1 3.6

1.2 C468 – Distance Between Witness and Boundary Marks

Introduction

Business rule test C468 checks each boundary mark to confirm that it complies with Rule 7.3.2 of the Rules for Cadastral Survey 2010.

Rule 7.3.2 defines the maximum distance between each boundary mark and its nearest witness mark. This contributes to good survey design.

What C468 does

The C468 test does the following for each boundary mark observed in the survey:

1) Determines the cadastral class of the mark by picking the most accurate survey class of the observations in the CSD connected to that mark.

2) Uses the mark cadastral class to determine the maximum allowed distance from a boundary mark to its nearest witness mark or Permanent Reference (e.g. 150m for Class A). The distance is measured by scribing an arc around each witness mark, rather than by connected vectors.

3) Calculates the distance from the boundary mark to all the witness marks in the survey.

4) Checks that there is at least one witness or Permanent Reference Mark within the maximum allowed distance from the boundary mark.

Notes

a) The C468 test does not accommodate the greater distances allowable for extensive rural boundary marks

b) Rule 7.3.2 does not specify that there needs to be a measured vector from a boundary mark to its nearest witness mark, therefore the test may pass even if there are no direct observations between the boundary and witness marks.

c) Rule 7.4.3(c) allows PRMs to be witness marks

1.3 C485– Proximity of PRM to Boundary

Introduction

Business rule test C485 checks each Permanent Reference Mark to confirm that it complies with Rule 7.4.2 of the Rules for Cadastral Survey 2010.

Rule 7.4.2 defines how close Permanent Reference marks should be to the survey. This contributes to good survey design.

What C485 does

The C485 test does the following for each PRM in the survey:

1) Identifies (for each class) whether there is a boundary mark close enough to the PRM to comply with Rule 7.4.2 (e.g. 300m for the distance to a Class A boundary mark). The distance is measured by scribing an arc around each PRM mark, rather than by connected vectors.

2) Of the three class tests (A, B & C), determines whether one of the sub-tests passes.

Notes

a) The C485 test does not accommodate the greater distances allowable for extensive rural boundary marks

b) Rule 7.4.2 does not specify that there needs to be a vector from a PRM to a boundary mark, therefore the test may pass even if there are no direct observations between the PRM and boundary marks.

1.4 C440– Horizontal datum connection

Introduction

Business rule test C440 checks that a CSN mark (order 6 or better) is part of the CSD where one exists within the distance criteria specified in Rule 4.2 of the Rules for Cadastral Survey 2010.

This contributes to good survey design by enforcing connection to appropriate geodetic control.

What C440 does

The C440 test does the following:

1) Identifies whether there is a CSN (6th order) mark in the survey
2) Checks that the CSN mark is close enough to a boundary mark to comply with Rule 4.2 (e.g. 500m for the distance to a Class A boundary mark).
3) If there is no CSN mark in the survey, check whether there is one in Landonline that should have been connected to.

Notes

a) Rule 4.2 does not specify that there needs to be c vector from a CSN to a boundary mark, therefore the test may pass even if there are no direct observations between the PRM and boundary marks.
b)

1.5 C182 – Internal Consistency Check

Introduction

Business rule test C182 checks the internal consistency of the survey to confirm that it complies with the Cadastral Rules 2010 Accuracy requirements. ie.

- Rule 3.1 Accuracy of non-boundary survey marks and
- Rule 3.3.1 Accuracy of boundary points and
- Rule 3.6 Accuracy of boundary witnessing

What C182 does

C182 does the following for the CSD:

1) Creates a least squares adjustment using only the observations submitted as part of the CSD.

2) Holds one mark fixed and runs the adjustment. The mark held fixed is that with the largest number of observations to it. If there are two or more marks with the same number of observations, then the mark with the lowest node id will be fixed.

3) Calculates node and vector accuracies and observation miscloses (residuals).

4) Checks the size of miscloses on all observations (including adoptions) for compliance with Rule 3.1 & 3.3.1. This assesses *implementation*.

5) Checks the coordinate accuracy of any node with a new observation to it for compliance with Rule 3.6. This assesses *design*.

6) Checks the accuracy of the calculated vector between any two nodes with new observations to them for compliance with Rule 3.6. This also assesses *design*.

Not affected by underlying data

Since only one mark is held fixed in the adjustment, the C182 test is not affected by any problems with the existing data already in Landonline. This means that even if there are large errors eg as a consequence of being in a non SDC area or from geodetic control, the survey can pass the C182 test.

Notes

a) Landonline does not test for the presence of short lines (eg in a traverse) which could have a significant impact on bearing accuracy. This needs to be assessed manually by looking at the CSD in the spatial window, or on the plan

   Short lines are a risk because the CSD may misrepresent the accuracy of the observations. This is because typically the surveyor observes the angle between two marks, but the CSD only includes the bearings calculated from the angles. Measuring angles on short lines is potentially inaccurate, as small plumbing or sighting errors lead to large angle errors. However in the CSD the large angle errors are not represented by large bearing errors, and so the test of survey design may fail to recognize the design weakness.

b) A set of marks that are only connected to another set of mark via a single marks (e.g. Hanging traverses) are not checked in this adjustment. They will need to be checked manually. However, if there is an SDC mark at each end of the hanging traverse, then a manual check is not necessary because the full/partial SDC adjustment provides a check on the hanging observation set.

1.6 C184 – Full/Partial SDC Check

Introduction

Business rule test C184 checks the CSD to confirm consistency with the existing data in Landonline. It only runs if the CSD is connected to at least one SDC mark.

There are two possible checks that can be run as part of the C184 test: the full SDC check and the partial SDC check. Only one of these two checks will run for any given dataset connected to SDC marks.

Full versus partial

The full SDC check runs if the following conditions are met:

1) The CSD connects to at least one SDC mark.

2) Every existing Landonline mark in the CSD is an SDC mark.

The partial SDC check runs if the following conditions are met:

1) The CSD connects to at least one SDC mark.

2) At least one existing Landonline mark in the CSD is not an SDC mark.

The key difference between the full and partial check is that the full check uses only those observations submitted as part of the CSD. The partial check uses the observations submitted as part of the CSD, but also brings in observations from CSDs already accepted into Landonline which share at least two marks in common with the new CSD.

What C184 does

C184 does the following for the CSD:

1) Creates a least squares adjustment using:
   a) only the observations submitted as part of the CSD (for the full SDC check) OR
   b) the observations submitted as part of the CSD, plus observations from CSDs already accepted into Landonline which share at least two marks in common with the new CSD (for the partial SDC check).

2) Holds all marks with SDC status fixed and runs the adjustment (calculating bearing swings if required).

3) Calculates observation miscloses.

4) Checks the size of miscloses on all observations in the new CSD (including adoptions) for compliance with Rules 3.1 & 3.3.1. This assesses *implementation*.

Notes

Pseudo Observations

If observations from another CSD already in Landonline have a surveyed class of "pseudo", they are not brought into the cadastral adjustment. Pseudo observations are not survey-accurate, but were most likely generated by digitising paper cadastral record maps.

Bearing Swings

For the full SDC check, a bearing swing is calculated if the CSD is not in terms of NZGD2000. This would be exceedingly rare, as CSDs where all the existing Landonline marks have SDC status should be in terms of NZGD2000 already.

For the partial SDC check, a bearing swing is calculated if the CSD is not in terms of NZGD2000. A bearing swing is also calculated for any existing Landonline observations brought into the adjustment which are not in terms of NZGD2000.

1.7 C185 – Underlying Survey Check

Introduction

A full or partial SDC check cannot be carried out when the CSD does not connect to any SDC marks (e.g. in some rural areas). In these situations, an underlying survey check is carried out using existing Landonline data.

Note: "Underlying" in this sense is in regard to the existing cadastre prior to integration of new Survey Information and is not directly related to the definition of "Underlying Parcels" as defined in the Cadastral Rules 2010.

What C185 does

C185 does the following for the CSD:

1) Creates a least squares adjustment using the observations submitted as part of the CSD, as well as the observations from all CSDs already accepted into Landonline which share at least two marks in common with the new CSD.

2) Holds one mark fixed. The mark held fixed is that with the largest number of observations to it. If there are two or more marks with the same number of observations, then the mark with the lowest node id will be fixed.

3) Runs the adjustment (calculating bearing swings if required).

4) Calculates observation miscloses.

5) Checks the size of miscloses on all observations in the new CSD for compliance with Rules 3.1 & 3.3.1. This assesses *implementation*.

Notes

No Underlying CSDs

In many cases, there are no adjoining or underlying CSDs to provide the additional data required for the underlying survey check. In these circumstances the C185 underlying survey check is identical to the C182 internal consistency check, except that relative accuracy and proximity tests are not carried out as part of the C185 check.

Bearing Swings

Bearing swings are calculated as required to ensure any existing Landonline observations brought into the adjustment are brought in terms of the CSD.

1.8 Capture Requirements for Running Business Rules

Introduction

The Landonline business rules that test survey accuracy are reliant on certain data characteristics being correctly captured.

This section outlines the circumstances in which the Landonline business rules are likely to be producing realistic results and gives some examples of situations in which business rule tests may not run correctly due to capture errors.

Correct data capture

If the required observation and node attributes (such as equipment type and mark purpose) have been correctly captured, then the observation accuracies will be correctly assigned. It can then be assumed that the business rule tests will work as designed (as long as actual measurements have been captured, rather than just calculated vectors – see 3.9 CSDs with Calculated Vectors on page 55).

Incorrect data capture

Incorrect capture of some or all of the observation and node attributes can invalidate the Landonline tests. This could lead to the approval of surveys that contain errors exceeding those permitted by the Rules for Cadastral Survey 2010. Therefore, it is important that capture is correct. The following examples provide some indications of the impact of incorrect data capture.

Example 1

A surveyor captures all the marks in a traverse with the node purpose "boundary". The observation accuracy of boundary observations is much less than that of traverse observations, so the surveyor's traverse has accuracies assigned which are too loose.

Landonline tests the traverse using the maximum permitted errors that are appropriate for boundaries. This could allow miscloses outside the Rules for Non boundary observations to go undetected, thus allowing an observation with a significant measurement error to become authorised in Landonline.

Example 2

Potential significant problem

A surveyor captures some boundary observations as Class B instead of Class A.
The C468 test, C485 test, C440 test which checks proximity of boundary marks to non boundary marks , may return some false positives due to the increased distances allowed

The adjustment reports may also be reporting information that the Surveyor may interpret as being satisfactory (eg a low SEUW) that would otherwise not have occurred due to inappropriate error estimates being applied and higher allowable tolerances under rules 3.3.1 and 3.6

Example 3	A surveyor uses GPS to do a survey in an area where the underlying plans are about 100 years old. The survey includes the use of adopted data from the old plans. The adopted data is captured with the equipment type of "unknown", but the *e-survey* capturer neglects to change back to "GPS" for the capture of the new data. Consequently, the accuracies on the GPS observations are the same as the accuracies for the old adopted data. If the old adopted data contains large errors, these will get distributed through the network into the GPS observations. This degrades the quality of the coordinates of the marks measured with GPS.

Part 2: Adjustment Messages

2.1 Overview

Introduction

Various error and warning messages may occur in pre-validation adjustment reports.

Part 2 of this document details what these messages mean, and why they occur. The focus is on the nine most frequent errors/warnings, which account for almost 99% of the messages.

To Note

Examples of the messages have been obtained from actual pre validation reports prior to the implementation of the Rules for Cadastral Survey 2010. Accordingly, rule references will not match pre-validation reports that are generated after 24 May 2010.

The implementation of the 2010 rules, changed mark purposes list. such as removal of "Origin" The 2002 examples used do not reflect these changes.

Common messages

The most common messages are:

1) Not enough information to calculate node
2) Parameters fixed automatically to avoid singularity
3) Not enough information to calculate northing (or easting)
4) No nodes are associated with this adjustment
5) Not enough information to calculate bearing swing
6) Possible [xx] degree error in bearing (or arc bearing)
7) Adjustment failed to converge
8) Sum of squared residuals value truncated to fit floating point format
9) Coordinate change [xx] exceeds allowable maximum

Errors versus warnings

- An error message indicates that the adjustment has not run to completion. Some or all of the parameters have not been calculated.

- A warning message indicates that the adjustment has run, but there were issues in the running of the adjustment.

What to do

If there is an error or warning message in the pre-validation report, follow these steps:

Step 1

Using the table on page 38, determine the possible causes of the message.

Step 2

Check the data for any capture errors. The adjustment report often provides information to help find capture errors, such as large misclose failures or large node movements. If capture errors are found, correct them and re-run pre-validation.

Step 3

If there is no capture error, or there are still adjustment errors after the capture has been corrected, note this in the survey report. If the errors have meant that the S-G's Rules have not been tested, then the survey report should provide alternative evidence of compliance with the Rules (such as details of traverse sheet miscloses).

2.2 Not Enough Information to Calculate Node

Message example

```
Not enough information to calculate node IB A DP 347912
(Ref Id: 3) (3)
Node automatically rejected from the adjustment
```

Reasons for message

There are two reasons for this error message:

1) The node is not connected (either directly or indirectly) to another node which is fixed in the adjustment, and so its coordinates cannot be calculated. The node and all the observations to it are removed (rejected) from the adjustment.
2) The adjustment has a node with only a single observation (bearing or distance) connecting to it (e.g. a bearing-only trig shot).

This message means that any observations connected to that node will NOT be checked by the adjustment.

Relationship to other validation messages

This warning message will often occur in conjunction with two other messages.

```
Note: [xx] parameters fixed automatically to avoid
singularity
```

(This message is located in the "ADJUSTMENT SUMMARY" section at the top of the report). See section 2.3 Parameters Fixed Automatically to Avoid Singularity on page 24.

```
[xx] observations were not tested (rejected from
adjustment)
```

(This message is located in the "SUMMARY OF REGULATION TESTS[1]" section, and may be associated with more than one of the rules being tested). See Example 1 on page 19.

These three messages often occur together because they are related to the same underlying issue (a lack of connectivity to a fixed node).

[1] Note that 'Regulation Tests' are the same as 'SG Rule Tests'. 'Regulation' is a historic term which has been replaced by 'Rule'.

Example 1

Below is an example of an internal consistency (C182) adjustment report highlighting this warning message. The primary warning message is shown in **bold** and the messages that have a relationship with the primary message are shown in ***italic bold***.
Note:This is a historic example, rule references contained in a pre-validation report after 24-May-2010 report will differ.

```
================================================================================
ADJUSTMENT SUMMARY
================================================================================

Number of observations:         36

Number of parameters:           34

Degrees of freedom:             2

Standard error of unit weight:    1.20

Note: 14 parameters fixed automatically to avoid singularity

================================================================================
SUMMARY OF REGULATION TESTS
================================================================================

Testing regulations: Surveyor-General's Rules 2002/2 for class II surveys

Test: Reg 28 and 26.2.b.i: Misclose of obs between boundary marks
  Tested for 18 observations of which 0 failed
  All observations were better than 0.09 times allowable misclose
  14 observations were not tested (rejected from adjustment)

Test: Reg 28 and 26.2.b.ii: Misclose of obs from boundary marks to witness marks
  This test was not used in the survey

Test: Reg 28 and 26.2.b.iii: Misclose of obs from boundary marks to origins
  Tested for 2 observations of which 0 failed
  All observations were better than 0.00 times allowable misclose

Test: Reg 28 and 26.2.b.iv: Misclose of obs between witness/traverse/origin marks
  Tested for 2 observations of which 0 failed
  All observations were better than 0.00 times allowable misclose

================================================================================
NOTES
================================================================================

Not enough information to calculate node Node ID 24281183 (24281183)
Node automatically rejected from the adjustment

Not enough information to calculate node Node ID 24356650 (24356650)
Node automatically rejected from the adjustment

Not enough information to calculate node Node ID 24397390 (24397390)
Node automatically rejected from the adjustment

Not enough information to calculate node Node ID 24443650 (24443650)
Node automatically rejected from the adjustment

Not enough information to calculate node Node ID 24507539 (24507539)
Node automatically rejected from the adjustment

Not enough information to calculate node Node ID 24571428 (24571428)
Node automatically rejected from the adjustment

Not enough information to calculate node Node ID 24577218 (24577218)
Node automatically rejected from the adjustment
```

Example 1
(continued)

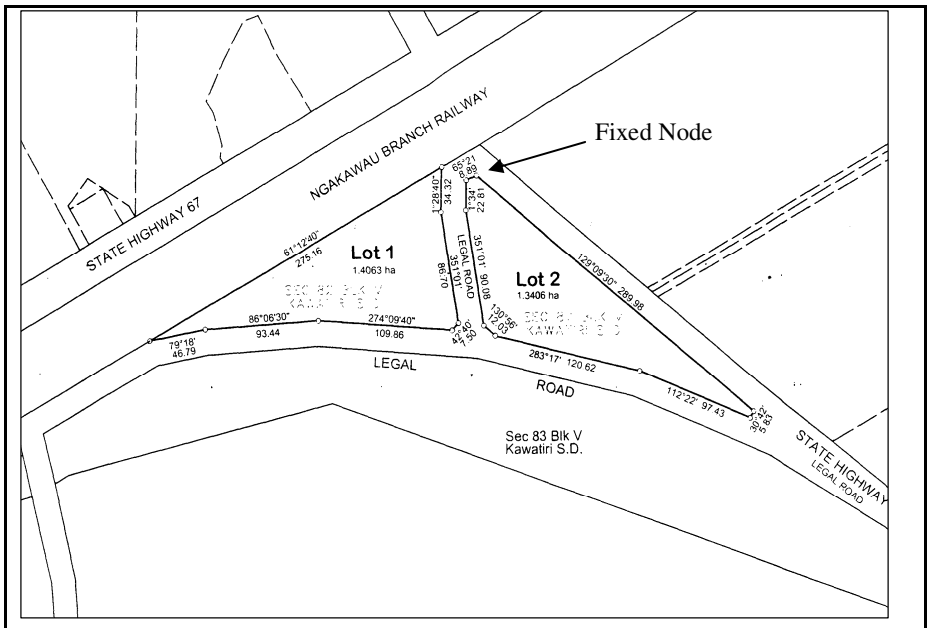


Figure 1: Plan image for Example 1.

The primary warning message: **Not enough information to calculate node** occurs because the two lots are not connected. The adjustment selects one node to hold fixed, which in this example is part of Lot 2. As there is no connection between the nodes forming Lot 1 and the fixed node in Lot 2, the adjustment cannot calculate coordinates for nodes in Lot 1. This leads to these nodes being automatically rejected.

The first related warning message appearing in the pre-validation report is: **Note: 14 parameters fixed automatically to avoid singularity**. In this example, the 14 parameters to which this message refers are the northing and easting values of the 7 nodes which were rejected in this adjustment. These rejected nodes needed to be held fixed in order for the adjustment to run to completion (the fixing of nodes is one step in the node rejection process). For practical purposes, this message can be ignored.

The second message that relates to the primary message: **14 observations were not tested (rejected from adjustment)** means that the vectors between the rejected nodes were not tested. Lot 1 is made up of 7 vectors, which is equivalent to 14 observations (7 bearings and 7 distances). These observations were not tested because the 7 nodes to which they are attached were rejected in the adjustment.

Example 2

Below is a second example internal consistency (C182) adjustment report highlighting this warning message. The primary warning message is shown in **bold** and the messages that have a relationship with the primary message are shown in ***italic bold***.
Note: This is a historic example, rule references contained in a pre-validation report after 24-May-2010 report will differ.

```
================================================================================
ADJUSTMENT SUMMARY
================================================================================

Number of observations:          46

Number of parameters:            42

Degrees of freedom:              4

Standard error of unit weight:     0.02

Note: 26 parameters fixed automatically to avoid singularity

================================================================================
SUMMARY OF REGULATION TESTS
================================================================================

Testing regulations: Surveyor-General's Rules 2002/2 for class III surveys

Test: Reg 28 and 26.2.c.i: Misclose of obs between boundary marks
   Tested for 20 observations of which 0 failed
   All observations were better than 0.00 times allowable misclose
   24 observations were not tested (rejected from adjustment)

Test: Reg 28 and 26.2.c.ii: Misclose of obs from boundary marks to witness marks
   This test was not used in the survey

Test: Reg 28 and 26.2.c.iii: Misclose of obs from boundary marks to origins
   Tested for 6 observations of which 0 failed
   All observations were better than 0.00 times allowable misclose

Test: Reg 28 and 26.2.c.iv: Misclose of obs between witness/traverse/origin marks
   This test was not used in the survey

================================================================================
NOTES
================================================================================

Not enough information to calculate node Node ID 21802207 (21802207)
Node automatically rejected from the adjustment

Not enough information to calculate node Node ID 21914063 (21914063)
Node automatically rejected from the adjustment

Not enough information to calculate node Node ID 22068019 (22068019)
Node automatically rejected from the adjustment

Not enough information to calculate node Node ID 22115001 (22115001)
Node automatically rejected from the adjustment

Not enough information to calculate node Node ID 22208019 (22208019)
Node automatically rejected from the adjustment

Not enough information to calculate node PEG SO 16952 (22394716)
Node automatically rejected from the adjustment

Not enough information to calculate node UNMARKED SO 17032 (22511174)
Node automatically rejected from the adjustment
```

Example 2
(continued)

Not enough information to calculate node Node ID 22623110 (22623110)
Node automatically rejected from the adjustment

Not enough information to calculate node Node ID 22716599 (22716599)
Node automatically rejected from the adjustment

Not enough information to calculate node PEG SO 17032 (37177475)
Node automatically rejected from the adjustment

Not enough information to calculate node PEG SO 16952 (39944217)
Node automatically rejected from the adjustment

Not enough information to calculate node PEG SO 16952 (39944218)
Node automatically rejected from the adjustment

Not enough information to calculate node PEG SO 16952 (39944219)
Node automatically rejected from the adjustment

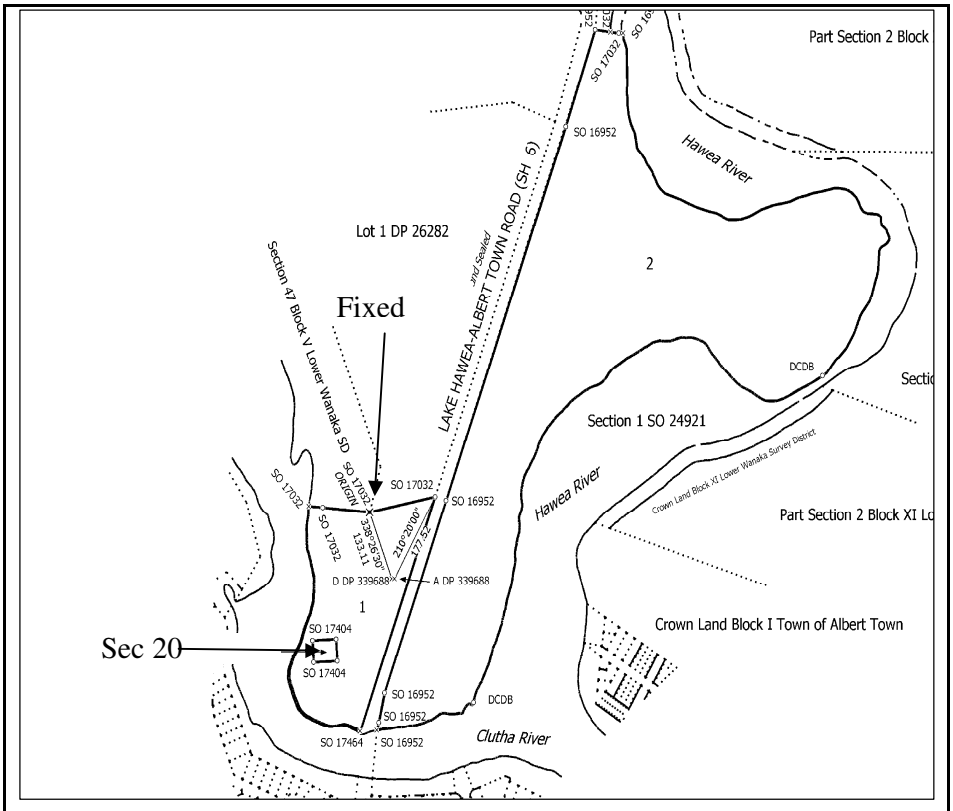


Figure 2: Plan image for Example 2.

The primary warning message: **Not enough information to calculate node** occurs because the three parcels are not connected. The adjustment selects one node to hold fixed, which in this example is part of Lot 1. As there is no connection between the nodes forming Lot 2 and Section 20, and the fixed node in Lot 1, the adjustment cannot calculate coordinates for nodes in Lot 2 and Section 20. This leads to these nodes being automatically rejected.

Example 2 (continued)

The first related warning message appearing in the pre-validation report is: **Note: 26 parameters fixed automatically to avoid singularity**. The 26 parameters to which this message refers are the northing and easting values of the 13 nodes (9 around Lot 2 and 4 around Section 20) which were rejected in the adjustment. These rejected nodes need to be held fixed in order for the adjustment to run to completion.

The second message that relates to the primary message: **24 observations were not tested (rejected from adjustment)** means that the vectors between the rejected nodes were not tested. Lot 2 is made up of 8 vectors (16 observations) and Section 20 is made up of 4 vectors (8 observations). This gives a total of 12 vectors (24 observations). These observations were not tested because the 13 nodes to which they are attached were rejected in the adjustment.

Notes

1) The fixing of nodes in an adjustment is an automated process. The *e-survey* capturer cannot force nodes to be held fixed.

2) Parcels such as Section 20 in Example 2 are sometimes referred to as "island parcels" or "donut parcels".

What to do (Suggestion only)

In the situation where nodes are not connected (directly or indirectly) to another node which is fixed in the adjustment, a connection could be provided using adopted (or calculated) observations.

In Example 1, there may be a survey plan that provides one or several observations connecting Lots 1 and 2. With Lots 1 and 2 being connected, the adjustment will be able to calculate coordinates for the nodes that would otherwise be rejected. This means the observations that would have been rejected will now get tested in the adjustment.

Note that although this action is optional, it may make it easier to demonstrate compliance with the S-G's Rules since the entire CSD will be tested by Landonline.

2.3 Parameters Fixed Automatically to Avoid Singularity

Message example

```
Note: 41 parameters fixed automatically to avoid singularity
```

Explanation

"Singularity" is a mathematical term which means that the parameters (mark coordinates or bearing swings) could not be calculated because there is not enough information (observations or fixed coordinates) to do so.

In order for the adjustment to run, these parameters are held fixed. That is, they are not calculated in the adjustment. This allows the adjustment to proceed, but it also means that the adjustment is not able to provide any information about the parameters.

For example, accuracy tests measure how accurately mark coordinates are calculated by an adjustment. If the coordinates are not calculated, then it is not possible to apply this test.

When a node is automatically fixed for this reason it is reported as 'rejected'. All observations in the adjustment that are connected to these rejected nodes are also rejected.

One way to interpret the above message would be:

Note: 41 parameters fixed automatically to ***enable adjustment to run***

Reasons for message

There are three reasons a specified parameter cannot be calculated:

1) The adjustment has a bearing swing parameter which cannot be calculated due to insufficient information.
2) A node is not connected (either directly or indirectly) to another node which is fixed in the adjustment, and so its coordinates cannot be calculated. The node, and all the observations to it, are rejected from the adjustment.
3) The adjustment has a node with only a single observation connecting to it (e.g. a bearing-only trig shot).

In all cases where nodes are rejected from an adjustment, this message will appear in the pre-validation adjustment report. More information about this message is given in these related sections:

- 2.2 Not Enough Information to Calculate Node (page 18)
- 2.4 Not Enough Information to Calculate Northing or Easting (page 25)
- 2.6 Not Enough Information to Calculate Bearing Swing (page 28)

2.4 Not Enough Information to Calculate Northing or Easting

Message example

```
Not enough information to calculate northing of node PEG (1)
DPS 78562 (Ref Id: 21) (27069502)
Node automatically rejected from the adjustment

Not enough information to calculate easting of node TRIG
TIKORANGI NO 2 (Ref Id: 502) (36725549)
Node automatically rejected from the adjustment
```

Reason for message

There are two reasons this error message occurs:

1) The adjustment has a node with only a single observation connecting to it (e.g. a bearing-only trig shot).
2) The adjustment has a bearing swing parameter which cannot be calculated due to a lack of fixed marks. This is only relevant to the full/partial SDC or underlying survey (C184 or C185) adjustment.

The second situation may occur where the CSD is in terms of New Zealand Geodetic Datum 1949 (NZGD49) or Old Cadastral Datum (OCD). It occurs when there are not enough SDC marks to calculate a bearing swing. In this case all nodes apart from the fixed node are automatically rejected from the adjustment. For further information see 2.6 Not Enough Information to Calculate Bearing Swing on page 28.

Relationship to other pre-validation messages

This warning message will often occur in conjunction with the following messages:

```
Note: [xx] parameters fixed automatically to avoid
singularity
```

(This message is located in the "ADJUSTMENT SUMMARY" section). See section 2.3 Parameters Fixed Automatically to Avoid Singularity on page 24.

```
[xx] observations were not tested (rejected from
adjustment)
```

(This message is located in the "SUMMARY OF REGULATION TESTS" section, and may be associated with more than one of the Rules for Cadastral Survey 2010 being tested). See Example 1 in section 2.2 Not Enough Information to Calculate Node on page 19.

```
Not enough information to calculate Bearing swing (arc sec)
for [xxxxxx]
Parameter automatically rejected from the adjustment
```

(This message is located in the "NOTES" section of the report). See section 2.6 Not Enough Information to Calculate Bearing Swing on page 28.

2.4 Not Enough Information to Calculate Northing or Easting
Continued

Example Below is an example of a hanging line which has only a bearing observation (IT VIII DPS 78562 - TRIG TIKORANGI NO 2).

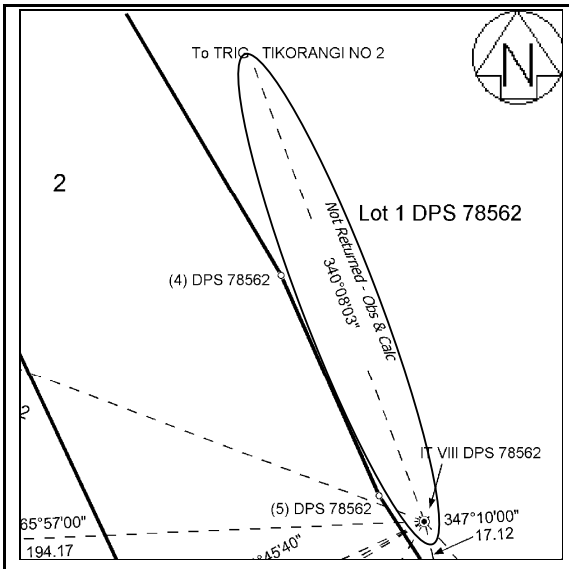


Figure 3: This survey has a hanging line with a bearing observation only (circled). `TRIG TIKORANGI NO 2` will be fixed and rejected in the adjustment. This will allow the adjustment to complete (find a solution).

The message that is displayed in the pre-validation report is:

Not enough information to calculate easting of node TRIG TIKORANGI NO 2 (Ref Id: 502) (36725549)
Node automatically rejected from the adjustment

2.5 No Nodes are Associated with this Adjustment

Message example

```
No nodes are associated with this adjustment
```

Reason for message

This error message occurs because the adjustment does not contain any observations. It contains aspatial information only. Therefore, no nodes are included.

Some Unit Plans are examples of aspatial CSDs.

2.6 Not Enough Information to Calculate Bearing Swing

Message example

```
Not enough information to calculate Bearing swing (arc sec)
for EDENTM1949
Parameter automatically rejected from the adjustment
```

Reason for message

There is not enough information in the adjustment (from observations and fixed marks) to calculate the bearing swing. This error message only occurs for non-NZGD2000 CSDs in the full/partial SDC adjustment or the underlying survey adjustment (C184 or C185). Landonline attempts to calculate a bearing swing to bring the CSD in terms of NZGD2000.

This message occurs fairly frequently for non-NZGD2000 CSDs, since there are usually not many SDC marks in the area covered by the survey – if there were, the survey could probably have been completed in terms of NZGD2000.

The overall outcome is that the C184 or C185 test does not run, because all of the nodes in the adjustment end up being rejected.

Consequently, the misclose tests normally carried out during the C184/C185 adjustment are not run.

2.6 Not Enough Information to Calculate Bearing Swing
Continued

Example

Below is an underlying survey (C185) adjustment report for an OCD CSD. Note:This is a historic example, rule references contained in a pre-validation report after 24-May-2010 report will differ.

ADJUSTMENT SUMMARY
==========
Number of observations: 21

Number of parameters: 21

Degrees of freedom: 0

Standard error of unit weight: 1.00

Note: 21 parameters fixed automatically to avoid singularity
==========
SUMMARY OF REGULATION TESTS
==========
Testing regulations: Surveyor-General's Rules 2002/2 for class III surveys

Test: Reg 28 and 26.2.c.i: Misclose of obs between boundary marks
8 observations were not tested (rejected from adjustment)

Test: Reg 28 and 26.2.c.ii: Misclose of obs from boundary marks to witness marks
8 observations were not tested (rejected from adjustment)

Test: Reg 28 and 26.2.c.iii: Misclose of obs from boundary marks to origins
4 observations were not tested (rejected from adjustment)

Test: Reg 28 and 26.2.c.iv: Misclose of obs between witness/traverse/origin marks
16 observations were not tested (rejected from adjustment)
==========
NOTES
==========
Not enough information to calculate Bearing swing (arc sec) for PLEAOCD
Parameter automatically rejected from the adjustment

Not enough information to calculate northing of node IT IV DP 10104 (36831425)
Node automatically rejected from the adjustment

Not enough information to calculate northing of node IT DP 19592 (39746307)
Node automatically rejected from the adjustment

Not enough information to calculate easting of node IT DP 6293 (39746311)
Node automatically rejected from the adjustment

Not enough information to calculate northing of node IR I DP 370833 (39746310)
Node automatically rejected from the adjustment

Not enough information to calculate northing of node Node ID 23717368 (23717368)
Node automatically rejected from the adjustment

Not enough information to calculate northing of node Node ID 23419250 (23419250)
Node automatically rejected from the adjustment

Not enough information to calculate northing of node Node ID 23485602 (23485602)
Node automatically rejected from the adjustment

Not enough information to calculate northing of node IR II DP 370833 (39746308)
Node automatically rejected from the adjustment

Because the bearing swing for PLEAOCD could not be calculated (only one node was held fixed), all nodes (except the node held fixed) have been rejected. Therefore, all observations connected to these rejected nodes are rejected.

2.7 Possible Error in Bearing or Arc Bearing

Message example

```
Warning: Possible 180 degree error in bearing (obs id 363)
from Peg (93) DP 379378 (Ref Id: 1031) (id 223) to
PEG (94) DP 379378 (Ref Id: 134) (id 136)

Warning: Possible 116 degree error in arc bearing (obs id
130318515)from PEG 7c SO 366539 (Ref Id: 1021) (id 222) to
PEG DP 11247 (Ref Id: 1131) (id 236)
```

Reasons for message

This warning message occurs because there is a large discrepancy between the value of the captured observation bearing and the value calculated by Landonline between the existing authoritative coordinates of the nodes.

There are three common causes of this warning message:

1) Bearing has been captured incorrectly.
2) Incorrect linking of the captured nodes with Landonline nodes.
3) Poor Landonline node coordinates (e.g. 8^{th}, 9^{th}, 10^{th} Order) – the error is in the calculated bearing.

Example

This is an example where a captured observation bearing, between nodes 22636659 and 39842990, significantly differs from the value calculated using the current authoritative coordinate of node 39842990. The following warning message appears in the pre-validation report:

Warning: Possible 105 degree error in bearing (obs id 32646959) from PEG (4) DP 50576 (id 22636659) to IT II DP 50556 (id 39842990)

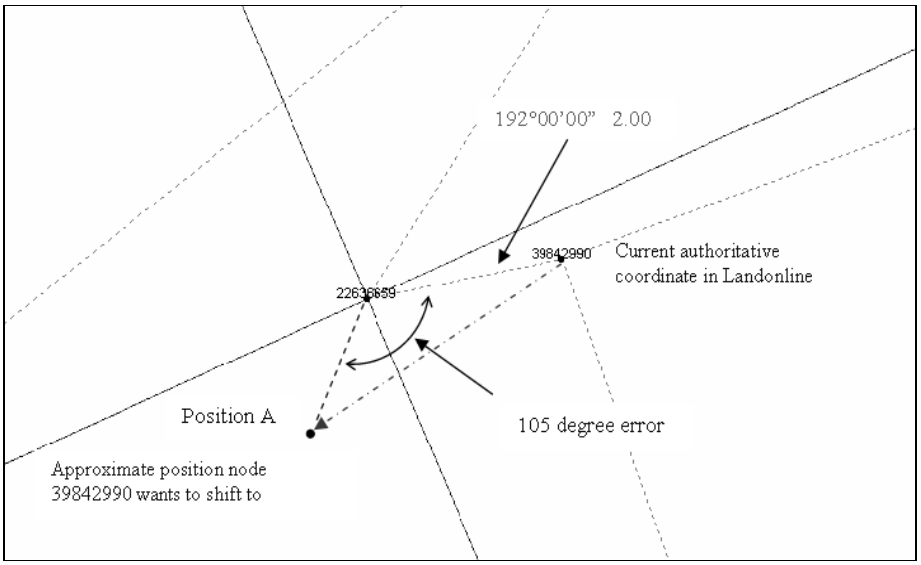


Figure 4: Node 39842990 has poor existing Landonline coordinates – its correct position is shown by Position A.

The captured observation of 192°00'00" looks more like 85°00'00" in the spatial window. The adjustment has calculated the bearing between the nodes 22636659 and 39842990 as 87°00'00". The observed bearing is therefore 105 degrees different from that calculated using the existing Landonline coordinates.

The Cadastral Maintain Network (CMN) adjustment run by LINZ, after approval of the CSD, will move the node to its correct position.

2.8 Adjustment Failed to Converge

Message example

```
Adjustment failed to converge after 10 iterations
```

Explanation

This error message means that the adjustment has not been able to calculate coordinates because of an unspecified problem with the observations or initial coordinates.

Least squares adjustment uses a number of iterations to determine the coordinates that best fit the observations. It starts with approximate coordinates for each end of an observation, and uses the misfit between the observations and the coordinates to calculate new, better-fitting coordinates. These are then used as the input coordinates to the next iteration. The adjustment is said to have "converged" when the coordinates are not significantly changed in an iteration.

Generally this works well, and the adjustment converges quickly in a few iterations.

Sometimes however the configuration of observations and coordinates causes the adjustment to either converge very slowly, or to diverge (at each iteration bigger adjustments to coordinates are calculated). In either case this message may occur.

This error means that the adjustment has not been completed. None of the pre-validation adjustment tests will have been carried out.

Reasons for message

There are three main reasons why an adjustment may fail to converge:

1) Gross errors in the captured data. For example, a bearing is 180° in error (reversed in capture when it should not have been or vice versa), or a 15.22m line was captured as 152.22m.
2) Incorrectly linked marks.
3) The existing coordinates are a long way from their correct position, causing the nodes in the adjustment to shift large distances to their correct position. Ten iterations may simply not be enough to allow convergence of the adjustment.

Example

This example shows a pre-validation adjustment report where the adjustment failed to converge.

```
================================================================
NON-CONVERGING NODES
================================================================================

The adjustment failed to converge because the coordinates of the following nodes
could not be determined.  This list shows the change to the node coordinates
at the last iteration of the adjustment

Id     Change  Name

0       0.037  IS IT DP 95531

1       0.025  IS VII DP 95591

2       0.030  Node ID 29014317

3       0.050  Node ID 29114740

================================================================
ERROR SUMMARY
================================================================

Warning: Possible 180 degree error in bearing (obs id 193681475)
        from ABD 1A DP 376721 (id 40943767) to ABD 2A DP 376721 (id 40343938)

Adjustment failed to converge after 10 iterations
```

In this example, the adjustment failed to converge because of a gross error in capture. The vector ABD 1A DP 376721 (id 40943767) to ABD 2A DP 376721 (id 40343938) had a 180° degree error - it had been reversed during capture when it should not have been.

What to do

The pre-validation adjustment report will provide a list of the coordinate changes for the non-converging nodes at the last iteration. This list of marks is found under the heading 'NON-CONVERGING NODES'.

1) If a node stands out as having a large coordinate change, it should be investigated by checking that the attached observations have been captured correctly.

2) If there is no error with the observations, then check that the nodes have been correctly linked.

2.9 Sum of Squared Residuals Value Truncated

Message example

```
Sum of squared residuals value truncated to fit floating
point format
```

Explanation

The Sum of Squared Residuals (SSR) value, which is used to calculate the Standard Error of Unit Weight (SEUW), is too large to be stored into the database. It is therefore truncated.

The sum of squared residuals is a measure of the total misfit of the observations with the final calculated coordinates. If it is this big, then something is wrong with the observations or coordinates.

Reasons for message

The SSR value will be large if the adjustment residuals are large. The adjustment residuals will be large if there is a gross error in the capture. The residuals need to be unusually large for this error to occur (perhaps tens or hundreds of metres in size).

This error message could occur because:

1) There are gross errors in the captured data.
2) Underlying data has been incorrectly captured (for the C184/C185 rules).
3) Captured nodes have been incorrectly linked with Landonline nodes.

In most cases where this message occurs, the adjustment will fail to converge. See 2.8 Adjustment Failed to Converge on page 32.

Example

This example shows the message "Sum of Squared Residuals value Truncated" **(bold)** in both the internal consistency adjustment and the partial SDC adjustment. Note that the adjustment reports show two other messages, a large misclose failure and a very large SEUW (all shown ***italic bold***). These are all good indicators that there is an error in the captured data.

*** Adjustment Report ***
****

*** Internal Consistency Adjustment ***

==========
NON-CONVERGING NODES
==========

The adjustment failed to converge because the coordinates of the following nodes could not be determined. This list shows the change to the node coordinates at the last iteration of the adjustment

1 3.009 SS6 ST108 (Ref Id: 1021)

2 3.724 SS4 ST103 (Ref Id: 1022)

3 3.724 SS5 ST104 (Ref Id: 1020)

4 2.305 NAIL VII DP 126362 (Ref Id: 1023)

5 1.981 IT III DP 126362 (Ref Id: 1024)

6 2.717 IT II DP 126362 (Ref Id: 1016)

7 8.287 NAIL I DP 126362 (Ref Id: 1017)

8 1.374 IS VII DP 330000 (Ref Id: 1015)

==========
ERROR SUMMARY
==========

Warning: Possible 176 degree error in bearing (obs id 16)
from IT VIII DP 126362 (Ref Id: 1002) (id 88184662) to NAIL VII DP 126362 (Ref Id: 1023) (id 88054661)

Adjustment failed to converge after 10 iterations

Sum of squared residuals value truncated to fit floating point format

*** Network Adjustment (Partial SDC) ***

==========
ADJUSTMENT SUMMARY
==========

Number of observations: 84

Number of parameters: 16

Degrees of freedom: 68

Standard error of unit weight: ***6307.22***

Example (continued)

Note:This is a historic example, rule references contained in a pre-validation report after 24-May-2010 report will differ.

```
================================================================================
SUMMARY OF REGULATION TESTS
================================================================================

Testing regulations: Surveyor-General's Rules 2002/2 for class I surveys

Test: Reg 28 and 26.2.a.i: Misclose of obs between boundary marks
  Tested for 22 observations of which 1 failed
  The worst failures are:
    Misclose on ellipsoidal distance (length 11.51) is 1.2 times tolerance
      Obs is from PEG I SO 335455 (Ref Id: 1026) (id 27) to PEG IIA DP 1256 (Ref Id: 1030) (id 32566571)

Test: Reg 28 and 26.2.a.ii: Misclose of obs from boundary marks to witness marks
  Tested for 10 observations of which 1 failed
  The worst failures are:
    Misclose on ellipsoidal distance (length 11.51) is 1.2 times tolerance
      Obs is from PEG I SO 335455 (Ref Id: 1026) (id 27) to PEG IIA DP 1256  (Ref Id: 1030) (id 32566571)

Test: Reg 28 and 26.2.a.iii: Misclose of obs from boundary marks to origins
  Tested for 26 observations of which 0 failed
  All observations were better than 0.85 times allowable misclose

Test: Reg 28 and 26.2.a.iv: Misclose of obs between witness/traverse/origin marks
  Tested for 44 observations of which 3 failed
  The worst failures are:
    Misclose on projection bearing (bearing 180 46 40) is 12863.3 times tolerance
      Obs is from IT VIII DP 126362 (Ref Id: 1002) (id 88184662) to NAIL VII DP 126362 (Ref Id: 1023) (id
88054661)
    Misclose on projection bearing (bearing 298 24 00) is 1.4 times tolerance
      Obs is from PEG III DP 126362 (Ref Id: 1028) (id 29) to IT VIII DP 126362 (Ref Id: 1002) (id 88184662)
    Misclose on projection bearing (bearing 306 41 13) is 1.4 times tolerance
      Obs is from PEG II SO 335455 (Ref Id: 1027) (id 28) to PEG III SO 335455 (Ref Id: 1028) (id 29)

================================================================================
NOTES
================================================================================

Warning: Possible 176 degree error in bearing (obs id 16)
      from IT VIII DP 126362 (Ref Id: 1002) (id 88184662) to NAIL VII DP 126362 (Ref Id: 1023) (id
88054661)

Sum of squared residuals value truncated to fit floating point format
```

The internal consistency adjustment failed to converge due to a gross capture error in the bearing observation between IT VIII DP 126362 (Ref Id: 1002) (id 88184662) and NAIL VII DP 126362 (Ref Id: 1023) (id 88054661). This vector was reported to have a possible 176° error in bearing and was 12863.3 times greater than the permitted tolerance in the misclose test for non boundary marks.

This observation was incorrectly captured as 180°46’40” when it should have been captured as 184°46’40”. The bearing observation should also have been reversed, but was not; therefore the observation had a very large residual which contributed to the sum of squared residuals being too large for Landonline to manage.

Because it was incorrectly captured by 4° and not reversed, the vector was reported to have a possible 176° error (180 – 4 = 176°).

2.10 Coordinate Change Exceeds Allowable Maximum

Message example

```
Coordinate change 2422.5 at node 36761106 (36 KAIAIA) exceeds
allowable maximum 1000.0
```

Explanation

This error occurs if the calculated change for a node coordinate exceeds the maximum permitted value. The adjustment fails if any coordinate is changed by more than this distance in any iteration.

The default value is 1000 metres.

Reasons for message

There are four main reasons this error message occurs:

1) The node (most likely a trig) has more than one bearing-only vector going to it, leading to the calculation of very poor intersected coordinates.
2) Gross errors in the captured data.
3) Gross errors in the underlying data.
4) The node has been linked incorrectly.

2.11 Summary of Messages and Causes

Introduction

The table below summarises the adjustment error and warning messages that may appear in a pre-validation report. Potential causes for each message are indicated by a tick (√).

Adjustment Error or Warning Message	Potential Cause										
	Node is part of a parcel not connected to rest of survey network	Node is connected to rest of survey network by only one observation (eg bearing-only trig shot)	No spatial data in CSD	Incorrect linking of marks and observations	Inaccurate non-SDC Landonline coordinates	Incorrect observation value	Bearing incorrectly reversed (or not reversed)	Node (most likely a trig) has multiple bearing-only vectors to it	Bearing swing is unable to be calculated (C184/C185 only)	Survey or capture errors in adjoining or underlying CSDs (C184/C185 only)	Errors in existing Landonline SDC coordinates (C184/C185 only)
Not enough information to calculate node	√	√									
Parameters fixed automatically to avoid singularity	√	√							√		
Not enough information to calculate northing or easting		√							√		
No nodes are associated with this adjustment			√								
Not enough information to calculate bearing swing									√		
Possible error in bearing or arc bearing				√	√	√	√				
Adjustment failed to converge				√	√	√	√			√	√
Sum of squared residuals value truncated to fit floating point format				√		√	√			√	√
Coordinate change exceeds allowable maximum				√		√	√	√		√	√

Part 3: Rule Tests

3.1 Overview

Introduction

This part discusses the Rules for Cadastral Survey 2010 tests that are run when the pre-validation adjustment is performed.

The primary purpose of these tests is to ensure that each CSD accepted into Landonline is correct and of sufficient accuracy.

There are two categories these Rule tests come under:

1) The misclose tests (survey implementation)
2) The vector and node tests (survey design)

As noted previously, if the adjustment has encountered errors then some or all of these tests may not run.

To Note

Examples have been obtained from actual pre validation reports prior to the implementation of the Rules for Cadastral Survey 2010. Accordingly, rule references will not match pre-validation reports that are generated after 24 May 2010.

What to do

If there are Rule failures in the pre-validation report, follow these steps:

Step 1

Using the table on page 57, determine the possible causes of the message.

Step 2

Check the data for any capture errors. Use the information in the adjustment report (ie the test failures) to help identify potential errors. If capture errors are found, correct them and re-run pre-validation.

Step 3

If there is no capture error, or there are still test failures after the capture has been corrected, note this in the survey report. The survey report needs to discuss why the CSD should still be accepted despite the failures.

3.2 C182 – Internal Consistency Check Fails

General causes of failure

In general the failure of the C182 test can be attributed to one of the following:

1) A capture error in the CSD.
2) An error in the design of the survey.
3) An error in the implementation of the survey.
4) Failure of the adjustment to complete (see Part 2: Adjustment for further information).

Note that this test may pass even though the data may not be sufficiently accurate. Sometimes this is indicated by a large standard error of unit weight (SEUW) in the pre-validation adjustment (as described in 3.5 C182 Check Passes with a High SEUW on page 44). This should always be checked.

Importance of C182

The purpose of this test is to check that the accuracy of the observations in the CSD against the Rules for Cadastral Survey 2010.

This test is unaffected by any issues with the geodetic control, existing SDC marks or survey data already in Landonline, so any failures relate directly to the CSD being tested.

Further information

The reasons for failure, and more detailed information about what to do, are described in the 3.6 Misclose Tests and 3.7 Relative Accuracy and Proximity Tests sections following.

3.3 C184 – Full/Partial SDC Check Fails

General causes of failure

The failure of the C184 check can be attributed to one of the following:

1) A survey or capture error in the CSD, which was not tested in the C182 check.
2) Errors in the existing Landonline data which are brought into the adjustment as part of the C184 partial SDC check.
3) Errors in the geodetic control or other SDC coordinates held fixed in the adjustment.
4) Failure of the adjustment to complete (see Part 2: Adjustment for further information).

Survey or capture errors causing failures

There are five survey/capture errors that cause most of the C184 misclose failures seen in adjustment reports.

Marks in the CSD incorrectly linked to existing Landonline marks

A mis-linking will show up as a large misclose in observations attached to the mis-linked mark and a high SEUW for the adjustment.

Survey or capture errors in observations which were 'hanging' in the C182 check

Often surveys contain hanging adopted traverses (usually to connect to geodetic control). Once other Landonline CSDs are brought in (for the partial SDC check), and SDC marks held fixed, the traverse may no longer be hanging, enabling errors to be identified.

A survey or capture error will show up as a misclose test failure in the observation with the error. Nearby observations may also fail the misclose test, as the error gets distributed through the survey network.

Inappropriate bearing swing calculation

Many NZGD2000 CSDs contain adopted OCD or NZGD49 data, which has a bearing swing applied (in many cases the swing will actually be zero). If the bearing swing is incorrectly calculated, this may result in misclose test failures for several or all of the OCD/NZGD49 bearing adoptions, if there are sufficient SDC marks or relevant underlying data in the adjustment.

Continued on next page

Survey or capture errors causing failures (continued)

Incorrect choice of coordinate system

Occasionally an incorrect coordinate system is chosen for a CSD, particularly where the survey is close to a meridional circuit boundary. If the misclose failures are mostly in the projection bearings, this could be the problem.

Inclusion of projection distances

If one or more ellipsoidal distances are failing the misclose tests, consider whether they could actually be projection distances. For example, if a distance has been calculated to a trig station using projection coordinates, then this distance would be a projection distance and needs to have a correction applied to convert it to an ellipsoidal distance. Projection distances can also occur in GPS surveys, where projection coordinates have been used to calculate vectors between marks.

Errors in the underlying data and SDC

The C184 check relies on the existing Landonline data (for the partial SDC check), and the SDC coordinates, being correct. Sometimes this is not the case, particularly in rural or peri-urban areas, or where the existing data is particularly old.

Occasionally the problem is due to errors in the coordinates of the geodetic control used in the CSD. This problem is generally limited to 5th Order geodetic control created through adoption of historical survey data. These marks can be easily identified in the Geodetic Database as they do not have an ellipsoidal height.

If the C182 check has passed, and any capture unchecked by the C182 check has been confirmed as correct, the C184 failure is probably due to problems with the existing Landonline data.

3.4 C185 – Underlying Survey Check Fails

General causes of failure

The failure of the C185 check can be attributed to one of the following:

1) A survey or capture error in the CSD, which was not tested in the C182 check.
2) Errors in the existing Landonline data which are brought into the adjustment as part of the C185 test.
3) Failure of the adjustment to complete (see Part 2: Adjustment for further information).

Specific causes of failure

The specific causes of failure are the same as those outlined in section 3.3 C184 – Full/Partial SDC Check Fails. The only difference is that since there are no SDC marks, poor mark coordinates will not cause this test to fail.

3.5 C182 Check Passes with a High SEUW

Introduction

Occasionally the C182 (internal consistency) business rule test passes, but the adjustment has a high SEUW (over 1.5). This sometimes indicates that there is a capture error in the data. At other times it is due to the poor quality of the data from which the CSD was compiled.

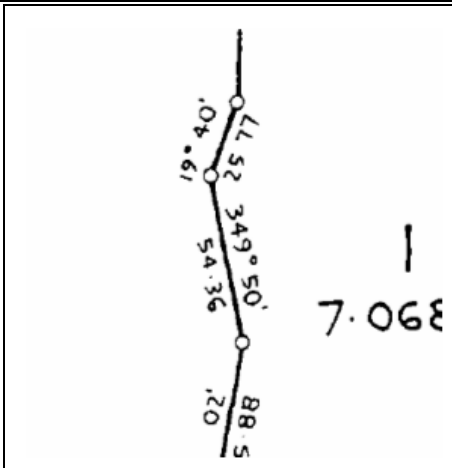
Why does C182 pass?

Normally a high SEUW is associated with the failure of a business rule test. This is because the error(s) which causes the high SEUW will usually cause some of the misclose tests to fail.

For Class B and C surveys, the tolerances permitted by the Surveyor-General's Rules are reasonably large. For example, Class B boundaries are permitted a maximum misclose of 0.30m + 0.006m/100m (that is similar to the 0.25m + 0.01m/100m for Class III as used in the following example of a. capture error that is distributed throughout the network, meaning that no individual line failed the C182 check, as part of the adjustment report.

The C182 test checks miscloses, and so is not able to detect an error that has been distributed among many observations.

Example



View Observations

Land District XXXXXXXXX
From PEG SO 1399 To PEG SO 1399

Co-ordinate System Amuri OCD

Reference Date	Survey Number	Bearing	Original Survey	Distance	Original Survey
01/10/2005	DP XXXX	349°50'00.000" ADPT	SO 1399	51.360 ADPT	SO 1399
	Bearing Accuracy:	0°00'02.079"	Distance Accuracy:	0.000	

*** End of Report ***

Figure 5: Screenshot of plan image and Landonline observation report, demonstrating the capture error.

In this example there is a 3m capture error in the distance between two nodes: the distance 54.36 on the plan was captured as 51.36.

The internal consistency adjustment report had a SEUW of 23.6, but no individual observations or vectors failed the tests.

The C182 check passed because this is a Class III compiled plan, which permits 0.25 + 0.01/100m between boundary marks. Since there was almost no redundancy in the adjustment, the 3m capture error got spread around the boundaries (there were no traverse observations to constrain the error). The misclose for each observation was less than 0.25m, so all individual observations passed and the overall C182 check passed, even though there was a large capture error.

After the capture error was corrected, pre-validation was re-run and the SEUW reduced from 23.6 to 1.9, which for old adopted data (in this example from 1895) is acceptable.

3.6 Misclose Tests

Introduction

Misclose tests check the implementation of any given CSD, by identifying capture errors or problems with the survey observations.

Survey implementation is governed by Rule 28 which tests the following:

1) Misclose of observations between boundary marks
2) Misclose of observations between boundary marks and witness marks
3) Misclose of observations between boundary marks and origins
4) Misclose of observations between witness/traverse/origin marks

Misclose tests are carried out in the C182, C184 and C185 checks.
Note:A Historic validation, message is used in the following examples until new examples based on the Cadastral rules for Survey 2010 can be obtained. In general messages based on the 2010 rule will be similar and reference Rule 3.1, 3.3.1 and 3.6.

Pre-validation message

```
Test: Reg 28 and 26.2.a.i: Misclose of obs between boundary
marks
Tested for 178 observations of which 0 failed
All observations were better than 0.40 times allowable
misclose
```

Reasons for failure

A misclose failure may be caused by an error in the data capture or an error in the survey work.

Capture Error

There are a number of capture errors which could cause a misclose failure:

1) Wrongly captured observation value (such as transposed figures).
2) Bearing incorrect by 180 degrees (this should be identified in the adjustment section of the pre-validation report by a warning message).
3) Wrong cadastral class of observation – this is easy to do where a survey is in terms of more than one cadastral class. This will affect which accuracy parameters are used when the test is run.
4) Wrong mark purpose (eg boundary mark captured as a non boundary mark). This also will affect which test parameters are run.
5) Observations incorrectly linked together (going to the wrong marks).
6) Incorrect coordinate system selection.

Survey Implementation Issue

Misclose failures in adopted observations are reasonably common, even where the capture is correct. This is because many historical surveys, particularly those completed prior to 1920, are not sufficiently accurate to meet current standards.

Misclose failures may also be related to the poor application of a bearing swing or inclusion of projection distances in the CSD.

Example 1

The first example shows an adjustment report that has failed the misclose tests during the running of the C182 check. Shown in **bold** are the S-G Rules being tested and in ***italic bold*** are the observations that failed the test. Note that in this example, none of the proximity and relative accuracy tests (Rule 13 and Rule 26) was run. This is because the CSD is compiled, with no new observations/marks.
Note:This is a historic example, rule references contained in a pre-validation report after 24-May-2010 report will differ.

*** Internal Consistency Adjustment ***

ADJUSTMENT SUMMARY
==========

Number of observations: 36

Number of parameters: 32

Degrees of freedom: 4

Standard error of unit weight: 9.66

SUMMARY OF REGULATION TESTS

==========

Testing regulations: Surveyor-General's Rules 2002/2 for class III surveys

Test: Reg 28 and 26.2.c.i: Misclose of obs between boundary marks
Tested for 18 observations of which 1 failed
The worst failures are:
Misclose on ellipsoidal distance (length 662.04) is 1.3 times tolerance
Obs is from PEG ML 20689 (id 27480501) to Node ID 27477217 (id 27477217)

Test: Reg 28 and 26.2.c.ii: Misclose of obs from boundary marks to witness marks
This test was not used in the survey

Test: Reg 28 and 26.2.c.iii: Misclose of obs from boundary marks to origins
Tested for 20 observations of which 4 failed
The worst failures are:
Misclose on ellipsoidal distance (length 662.04) is 2.1 times tolerance
Obs is from PEG ML 20689 (id 27480501) to Node ID 27477217 (id 27477217)
Misclose on projection bearing (bearing 273 07 20) is 1.3 times tolerance
Obs is from PEG ML 20689 (id 27480501) to Node ID 27477217 (id 27477217)
Misclose on projection bearing (bearing 246 48 00) is 1.3 times tolerance
Obs is from Node ID 27479841 (id 27479841) to Node ID 27478725 (id 27478725)
Misclose on projection bearing (bearing 183 39 00) is 1.1 times tolerance
Obs is from Node ID 27479853 (id 27479853) to Node ID 27479841 (id 27479841)

Test: Reg 28 and 26.2.c.iv: Misclose of obs between witness/traverse/origin marks
Tested for 10 observations of which 3 failed
The worst failures are:
Misclose on ellipsoidal distance (length 321.87) is 2.1 times tolerance
Obs is from PEG ML 5906 (id 40396316) to PEG ML 5906 (id 40396312)
Misclose on projection bearing (bearing 11 23 00) is 1.5 times tolerance
Obs is from PEG ML 5906 (id 40396312) to PEG ML 5906 (id 40396313)
Misclose on ellipsoidal distance (length 106.62) is 1.3 times tolerance
Obs is from PEG ML 5906 (id 40396315) to PEG ML 5906 (id 40396316

Example 1
(continued)

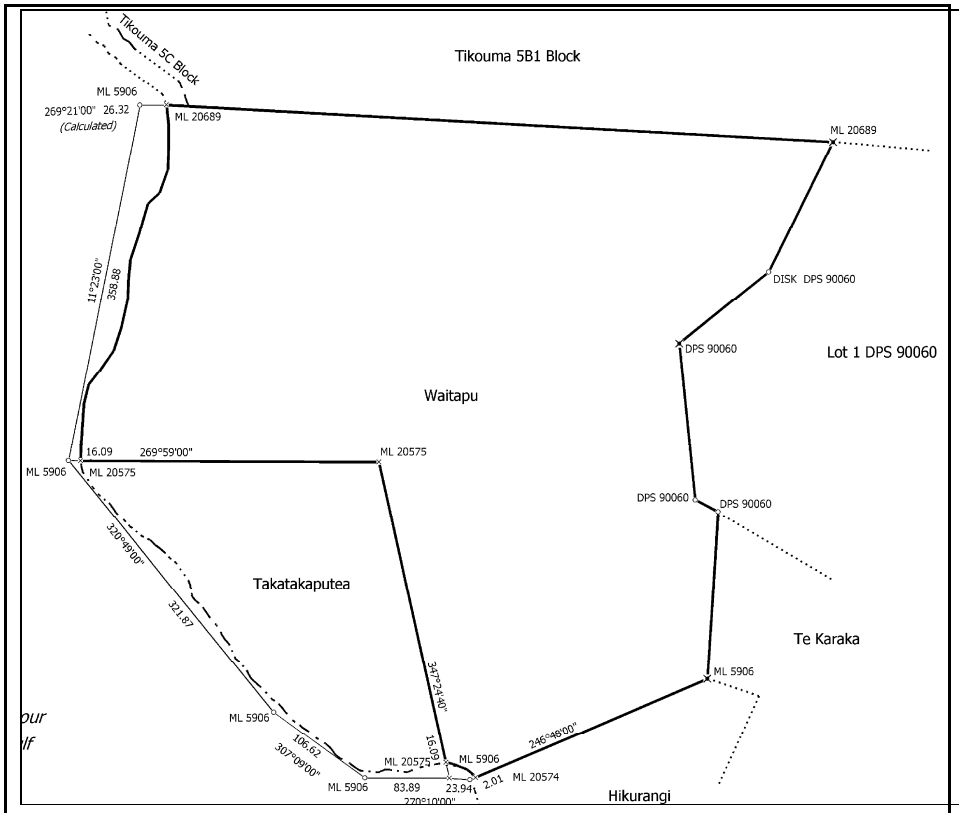


Figure 6: Screenshot of plan for Example 1.

The first test, **Reg 28 and 26.2.c.i: Misclose of obs between boundary marks**, has a failed observation between PEG ML 20689 (id 27480501) and Node ID 27477217 (id 27477217). This observation misclose was reported to be 1.3 times greater than the permitted tolerance. The observation was checked to eliminate any capture or survey error. No such error was found. The failure is therefore assumed to be related to the quality of the source data, which is an 1881 plan.

The second test, **Reg 28 and 26.2.c.ii: Misclose of obs from boundary marks to witness marks**, was not tested because the CSD does not contain any witness marks.

The third test, **Reg 28 and 26.2.c.iii: Misclose of obs from boundary marks to origins,** reported four observations that failed. In this survey, the three origin marks were also boundary marks. The data were checked for capture errors, and none were found.

The fourth test **Reg 28 and 26.2.c.iv: Misclose of obs between witness/traverse/origin marks**, reported 3 failures. Again, in the absence of any apparent capture errors, the misclose failures may be attributed to the quality of the original data from which this plan was compiled.

Example 2

Below is an example of the internal consistency (C182) adjustment report for a compiled CSD that has failed a misclose test. Shown in **bold** are the Rules being tested and in ***italic bold*** are the observations that failed the test.

ADJUSTMENT SUMMARY
==========

Number of observations: 42

Number of parameters: 8

Degrees of freedom: 34

Standard error of unit weight: 40.88

==========
SUMMARY OF REGULATION TESTS
==========
Testing regulations: Surveyor-General's Rules 2002/2 for class I surveys

Test: Reg 28 and 26.2.a.i: Misclose of obs between boundary marks
Tested for 38 observations of which 1 failed
The worst failures are:
Misclose on projection bearing (bearing 159 58 15) is 78.7 times tolerance
Obs is from PEG DP 57811 (Ref Id: 14) (id 23258382) to PEG DP 57811 (Ref Id: 15) (id 23341224)

Test: Reg 28 and 26.2.a.ii: Misclose of obs from boundary marks to witness marks
This test was not used in the survey

Test: Reg 28 and 26.2.a.iii: Misclose of obs from boundary marks to origins
Tested for 4 observations of which 0 failed
All observations were better than 0.13 times allowable misclose

Test: Reg 28 and 26.2.a.iv: Misclose of obs between witness/traverse/origin marks
This test was not used in the survey

The first test, **Reg 28 and 26.2.a.i: Misclose of obs between boundary marks**, has one failed observation. The observation that failed is reported to be 78.7 times greater than the permitted tolerance. This failure is due to the incorrect capture of the bearing between PEG DP 57811 (Ref Id: 14) (id 23258382) and PEG DP 57811 (Ref Id: 15) (id 23341224). The bearing of 159°58’15” should have been 154°58’15”. The high SEUW, 40.88, is also a good indicator of a capture error.

The second test, **Reg 28 and 26.2.a.ii: Misclose of obs from boundary marks to witness marks**, was not used in this survey. This test was not used because this CSD is a compiled plan that had no survey information; therefore no witness marks were captured.

The third test, **Reg 28 and 26.2.a.iii: Misclose of obs from boundary marks to origin and traverse marks**, has no failures. Although there is no survey information captured in this CSD, the test still ran because one boundary mark was captured with the purpose origin-boundary.

The fourth test, **Reg 28 and 26.2.a.iv: Misclose of obs between witness/traverse/origin marks**, was not used in the survey. As with the second test, it was not used because there is no survey information.

3.7 Relative Accuracy and Proximity Tests

Introduction

These tests enable the quality of the survey design to be assessed. They include both node (mark) and vector (observation) tests.

Under the Cadastral Rules for Survey 2010 Rules the rule references are

4.2 Horizontal Datum Connection,
7.3.2 Number and distance of witness marks
7.4.2 Distances between Permanent references marks and a boundary point
3.1 Accuracy of non boundary survey marks
3.3.1 Accuracy of boundary points
3.6 Accuracy of Boundary Witnessing

Which (with the exception of the horizontal datum connection and distances for PRMs) are equivalent to the tests undertaken for S-G Rules 2002, rule 13 and 26 test the following:

- Relative accuracy between boundary marks with new observations to them
- Relative accuracy between boundary marks with new observations to them and witness marks
- Proximity of boundary marks with new observations to them to witness marks
- Relative accuracy between boundary marks with new observations to them and origin and traverse marks
- Relative accuracy between witness/traverse/origin marks with new observations to them
- Proximity of natural boundary fixes to witness marks

Relative accuracy and proximity tests are only carried out in the C182 check.

Pre-validation message example

```
Test: Reg 26.2.b.i: Relative accuracy of boundary marks

Test: Reg 26.2.b.ii and 13.b.i: Relative accuracy and
proximity of boundary marks to witness marks
```

Both Rule 13 (proximity of marks) and Rule 26 (relative accuracy) tests are being carried out.

Reasons for failure

A relative accuracy test failure may be caused by an error in the data capture or poor survey design.

Capture Error

There are a number of capture errors which could cause a relative accuracy test failure:

1) Wrong cadastral class of observation – this is easy to do where different parcels in the same survey have different cadastral classes.
2) Wrong node purpose (eg boundary node captured as a traverse node).
3) Wrong equipment type (it is easy to forget to change this when moving between the capture of adopted and newly observed data).

Note that a capture error in the value of an observation will *not* cause the relative accuracy test to fail.

Survey Design Issue

There are several survey design features which may cause a CSD to fail the relative accuracy tests:

1) Failure to observe between two nearby marks.
2) Failure to observe between a new boundary mark and its nearest witness mark.

Failure to position a witness mark in close enough proximity to a boundary mark.

Example

This example shows a relative accuracy test that failed (***bold italic***) in the internal consistency (C182) adjustment.

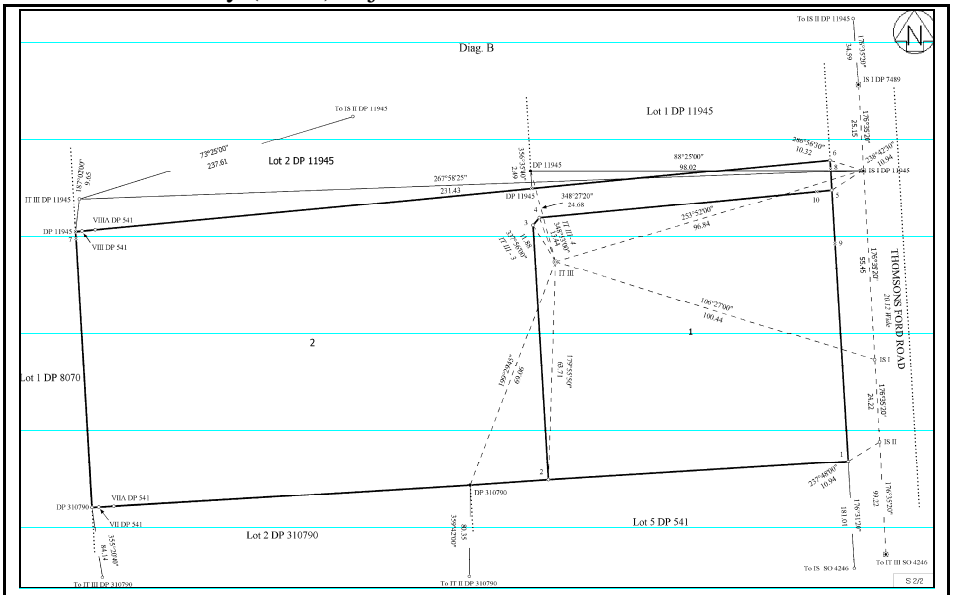


Figure 7: Screenshot of plan relating to the relative accuracy results shown below.

Test: Reg 26.2.a.i: Relative accuracy of boundary marks
Tested for 78 vectors of which 0 failed
All vectors were better than 0.41 times allowable error

Test: Reg 26.2.a.ii and 13.a.i: Relative accuracy and proximity of boundary marks to witness marks
Tested at 13 marks of which 1 failed
The worst failures are:
Mark UNMK 7 DP 399852 (Ref Id: 1031) (Id 32)

Test: Reg 26.2.a.iii: Relative accuracy of boundary marks to origins
Tested for 39 vectors of which 0 failed
All vectors were better than 0.48 times allowable error

Test: Reg 26.2.a.iv: Relative accuracy of witness/traverse/origin marks
Tested for 21 vectors of which 0 failed
All vectors were better than 0.35 times allowable error

Test: Reg 13.a.ii: Proximity of natural boundary fix to witness marks
This test was not used in the survey

The first test: **Reg 26.2.b.i: Relative accuracy of boundary marks**, checks the accuracy between boundary marks that have new observations to them. It tests the vector between every possible pair of new or old boundary marks, even if there are no direct observations between the marks. In this CSD there are 13 boundary marks, including the old mark on the western boundary of Lot 1 DP 11945. There are 78 possible combinations for these 13 marks, so 78 vectors are tested and passed.

The second test **Reg 26.2.b.ii and 13.b.i: Relative accuracy and proximity of boundary marks to witness marks**, checks the accuracy of each new or old boundary mark relative to its witness mark. In this example there are 13 boundary marks that have new observations to them, so there are 13 tests applied. The one mark which fails (UNMK 7 DP 399852) is on the western boundary of Lot2

Example (continued)

UNMK 7 DP 399852 is more than 125m from the nearest witness mark (Rule 13 permits a maximum of 125m for a Class I survey), which causes the failure. This mark is 139m from the closest witness mark, IT III. However, UNMK 7 DP 399852 is an easement boundary position; therefore the western boundary of Lot 2 does not need to be monumented. This failure can be dealt with by providing an explanation in the survey report.

Note: *This failed test will also show up in the section of the pre-validation report headed "The following rules may indicate a discrepancy with the Survey CSD which will need to be either corrected or covered in the Survey Report". In this section will be the following message: "C068 - Warning - S26 The following boundary marks are further than the regulation maximum distance from a witness mark".*

The third test: **Reg 26.2.b.iii: Relative accuracy of boundary marks to origins**, checks the relative accuracy of the vector between each boundary mark that has new observations to it and each origin in the survey. The test checks every possible pair of boundary and origin marks, even if there are no direct observations between them. There are 3 origin marks and 13 boundary marks in this CSD, giving 39 possible combinations of these marks. In this example, all vectors pass.

The fourth test **Reg 26.2.b.iv: Relative accuracy of witness/traverse/origin marks**, checks the relative accuracy of the new vectors between pairs of witness/traverse/origin marks. There are 7 witness/origin/traverse marks captured with new observations between them, giving 21 possible mark combinations. All vectors pass in this CSD.

The fifth test **Reg 13.b.ii: Proximity of natural boundary fix to witness marks**, tests whether natural boundary fixes are within the specified distance to the nearest witness mark. There are no natural boundaries in this CSD, so this test is not run

3.8 Untested Accuracy Rules

Introduction

In many cases, various Rules are not tested for a particular CSD. This is because Landonline looks at the data in the CSD and determines which tests are relevant.

Explanation

Below is a list of possible reasons why tests do not get run.

- **Misclose of obs between boundary marks**
  Examples of CSDs where this Rule test may not be used are Survey Information, Boundary Reinstatement, Digital SOs, Redevelopment Unit plan with survey information, Unit plan with survey information, Flat Plan with survey information, Easement plan with survey information, or any other CSD where there are no vectors captured between boundary nodes.

- **Misclose of obs between non-boundary marks**
  This is not tested where the CSD has been captured with no witness, traverse or PRM marks (no survey information). CSDs with no survey information are a good example.

- **Relative accuracy of boundary marks**
  This test is not used where a CSD has captured no new boundary marks. Two or more are needed for the test to run.

- **Relative accuracy and proximity of boundary marks to witness marks**
  This test is not used where a CSD has no new boundary marks captured. Likewise if the CSD has new boundary marks but no witness marks (possibly due to a capture error), then this test will not be carried out. If the CSD has captured origin/witness marks, but no witness marks, then this test will not be used.

- **Relative accuracy of non-boundary marks**
  If a CSD has been captured with no survey information, then this test is not used in the survey. Compiled CSDs with no survey information are a common example.

3.9 CSDs with Calculated Vectors

Introduction

The Landonline CSD pre-validation tests assume that directly measured observations are being submitted as part of the CSD.

For surveys carried out by conventional total station traversing, this assumption is fairly reasonable. For surveys carried out using GPS, the assumption may not be true in some circumstances.

If this assumption is untrue, then the pre-validation adjustments will not correctly assess the quality of CSD design and implementation.

Measured GPS vectors

A measured GPS vector is one where each end of the vector was simultaneously occupied by a GPS receiver. If these measured observations (or an average of them) are submitted as part of the CSD, then the pre-validation adjustment will be reliable.

Calculated GPS vectors

The nature of GPS is such that it is sometimes more useful to submit calculated vectors, which are based on the measured vectors. These calculated vectors will have observational errors which are slightly larger than the measured vectors from which they were calculated.

For example, if a 100m vector is calculated between two measured vectors 5km long, the error on the 100m vector is a combination of the errors on the 5km vectors. This will be quite different to the error on a 100 metre GPS measured vector.

However, Landonline treats the calculated vector as if it has been directly measured and calculates an error for the vector accordingly. This can lead to errors being assigned to calculated GPS vectors which are far smaller than they should be.

This will mean that the relative accuracy tests are far more likely to pass than they would be if the measured vectors were submitted. There is a likelihood of “false positives” in the testing of the Rules at pre-validation.

Misclose tests

One of the best ways of calculating vectors is to carry out a least squares adjustment. Often the calculated vectors submitted have been generated by adjustment, rather than from the unadjusted measurements, which means the misclose in the work is zero.

If this is the case, the Landonline misclose tests will always pass, irrespective of any actual errors in the survey.

3.9 CSDs with Calculated Vectors Continued

Survey report

Where CSDs with large numbers of calculated vectors are submitted, the survey report needs to cover in detail the steps taken to ensure that the survey complies with the Rules. Relevant supporting documentation should be attached (such as the output from a least squares adjustment) and an explanation given as to how this shows that the standards have been met. Another option is to choose a couple of the vectors most at risk of failure (usually the shortest vectors calculated from the longest observations) and do a manual calculation to prove that these lines comply (and therefore so does every other vector).

It would not be sufficient simply to state that the pre-validation adjustments had no failures, since these tests will always pass in some circumstances, as discussed.

3.10 Summary of Rule Failures and Causes

Introduction

The table below summarises the S-G Rule tests that appear in the pre-validation report. Potential causes of failure for each test are indicated by a tick (√).

	Potential Cause of Failure														
	Capture Error							Survey Issue						Other	
	Incorrect observation value	Bearing 180 degrees out	Incorrect cadastral class	Incorrect node purpose	Incorrect equipment type	Incorrect linking of marks and observations	Incorrect coordinate system selected	Incorrect bearing swing calculation	Poor accuracy of adopted work	Error in new measured or calculated survey work (including use of projection distances)	Failure to observe between two close marks	Failure to observe between a new boundary mark and its nearest witness mark	Failure to position a witness mark in close enough proximity to a boundary mark	Survey or capture errors in adjoining or underlying CSDs (C184/C185 only)	Errors in existing Landonline SDC coordinates (C184 only)
Misclose of obs between boundary marks	√	√	√	√		√	√	√	√	√				√	√
Misclose of obs from boundary marks to witness marks	√	√	√	√		√	√	√	√	√				√	√
Misclose of obs from boundary marks to origins	√	√	√	√		√	√	√	√	√				√	√
Misclose of obs between witness/traverse/origin marks	√	√	√	√		√	√	√	√	√				√	√
Relative accuracy of boundary marks			√	√	√						√				
Relative accuracy and proximity of boundary marks to witness marks			√	√	√						√	√	√		
Relative accuracy of boundary marks to origins			√	√	√						√				
Relative accuracy of witness/traverse/origin marks			√	√	√						√				
Proximity of natural boundary fix to witness marks			√	√	√							√	√		
SEUW greater than 1.5	√	√	√	√	√	√	√	√	√	√				√	√

Appendices

Appendix A: Design vs Implementation Examples

The difference: Example 1	This example shows the difference between survey design and implementation. An experienced Licensed Cadastral Surveyor (LCS) goes into the field to do a survey with a graduate surveyor. The LCS shows the graduate surveyor where to place the traverse marks (the geometry) and tells them which equipment to use (the observation accuracy). The survey is well-designed for accuracy. The LCS goes back to the office and leaves the graduate to do the survey. Due to inexperience with the equipment, the graduate surveyor makes some blunders when observing the lines for the survey. These errors show up as large miscloses. In this case, the survey would pass Landonline's "accurate design" tests but would fail the "accurate implementation" tests.

Why test design? Example 2	Given the example above, it might seem that the "accurate design" test is unnecessary. If the survey has small residuals, then surely this means that the observations have been made accurately and the survey can be accepted as accurate? Implementation alone is not a sufficient test of survey accuracy because it can only assess accuracy where two marks have an observation between them. Consider the following example: The LCS purchases some new GPS equipment. The salesperson advises that it can accurately measure vectors up to 10km long. So the LCS places one GPS receiver on a known point on the roof of the office and sends the graduate surveyor out to do a survey 10km away. The graduate surveyor is experienced at using GPS and is able to measure the 10km lines so that the miscloses are only 3cm, on average. This is well within the Rule 3.1 tolerances for this length of line. Two of the witness marks in the survey are separated by 100m. As part of the firm's QC process, the LCS uses a total station to measure between these two witness marks and finds that the measurement differs by 4cm from the GPS coordinates, failing Rule 3.1. This happened because the survey was designed badly. It did not account for the fact that while the accuracy standards would be met for the long GPS vectors, they would not be met for the unmeasured shorter vectors between marks. (Note the same issues would also have occurred under rule 3.3.1 had the Surveyor instead been placing boundary marks.) In this case, the survey would pass Landonline's "accurate implementation" tests but would fail the "accurate design" tests.

Appendix B: Observation Accuracy Estimates for CSDs

Introduction

The tests of survey design accuracy are based upon the geometry of the survey and the expected accuracy of the observations.

The geometry of the survey is known from the mark coordinates.

The real observation accuracies are based upon a large number of complex factors, such as the equipment, observing conditions, skill of the operator, quality of the survey marks, and so on. In practice these complex factors cannot be realistically assessed. Instead, there are five observation characteristics which Landonline uses to arrive at an estimated accuracy value:

1) Cadastral class
2) Observation type
3) Equipment type
4) Node purpose
5) Length of the observed vector

Each of these is discussed in turn below.

Cadastral class

The cadastral class of an observation is an indication of the accuracy that the survey is required to achieve, dependent upon the purpose of the observation. From most accurate to least, the cadastral classes are:

1) Class A
2) Class B
3) Class C
4) Class D

Observation type

Four observation types are used in CSDs. These are:

1) Bearing
2) Distance
3) Arc length
4) Chord bearing (for an arc)

Generally Landonline assigns the same estimated accuracy (when expressed as a distance error from one end of the line to the other) to each data type. The exception is where the equipment type is "Theodolite and EDM" (see below). In this case the distances and arc lengths are assumed to be more accurate than the bearings and chord bearings.

Appendix B: Observation Accuracy Estimates for CSDs
Continued

Equipment type

Observations in CSDs may be assigned one of four equipment types - each of which has an expected accuracy. In order of decreasing accuracy (for typical length observations) they are:

1) Theodolite / EDM (total station)
2) Theodolite / steel band
3) GPS
4) Unknown
5) Old adopted

Old adopted' is to allow lower accuracy weighting to be assigned to adoptions from very old surveys that are known to be of a low accuracy.

For longer lines (more than about 5km), the GPS observations are expected to be more accurate than other types.

Mark purpose

The expected accuracy is dependent upon the quality of the physical marks at the vector endpoints. This is estimated in Landonline based upon the purpose of the nodes in the survey. The purpose can be one of :

1) Boundary defined by survey
2) Natural Boundary defined by adoption
3) Origin-Boundary accepted
4) PRM
5) PRM / Boundary
6) Traverse
7) Witness-Boundary
8) Witness

Vector length

Measurement accuracy decreases as the observed vector length increases.

Appendix B: Observation Accuracy Estimates for CSDs
Continued

Factors not considered

There are some factors which *do not* contribute to the estimated accuracy of cadastral observations. Two of these are mentioned here as there has been some confusion in the past as to how these impact on observation accuracy.

Survey Date

This is not used to assign accuracies to observations. This is because the date of survey only affects survey accuracy indirectly. It is the change in equipment type which actually results in recent surveys being more accurate than older surveys.

Surveyed Class

The surveyed class refers to the source of the observation. Common values are:

1) Measured
2) Calculated
3) Adopted
4) Pseudo

The surveyed class is not used to assign accuracies to observations because once again it is actually the equipment type which is the determiner of observation accuracy. For example, an adoption included in a CSD could be 1 month old or 150 years old – the surveyed class of "adopted" is therefore not a good indicator of accuracy.

EDS survey conversion

When EDS (NZ) Ltd captured and adjusted the historical survey data used to populate Landonline, they did assign observation accuracies based on survey date and surveyed class. This is because in most cases it would have been difficult or impossible to ascertain with certainty the appropriate equipment type for the survey. With new CSDs being submitted to LINZ, this is not an issue.