SNAP Guidelines for GNSS Geodetic Control – CSV files

SNAP version 2.3.60
National Geodetic Office

Date: 1 February 2013

Contents

1. Terms and Definitions

For the purposes of this guideline, the following terms and definitions apply.

Term/abbreviation	Definition
Constrained adjustment	Adjustment where all control stations are held fixed
CORS	Continuously Operating Reference Station
CSV	Comma-separated values (CSV) file format, stores tabular data (numbers and text) in plain-text form
GNSS	Global Navigation Satellite System
Least squares	Statistical approach used by SNAP to evaluate co-ordinates and their errors
LINZ	Land Information New Zealand
Minimally constrained adjustment	Adjustment where a single (control) station is held fixed
NGO	National Geodetic Office
NZGD2000	New Zealand Geodetic Datum 2000 – the official geodetic datum for New Zealand
SEUW	Standard Error of Unit Weight
SNAP	Survey Network Adjustment Package

2. Forward

SNAP (Survey Network Adjustment Package) is a suite of programs for adjusting the co-ordinates in a survey network to best fit the observed data. SNAP uses a statistical method known as Least Squares (Section 7.1) to distribute errors and evaluate unknown co-ordinates.

This software is provided with no warranty and Land Information New Zealand (LINZ) does not offer any support for this software (See SNAP **Help | About** for more information).

2.1. Background and Scope of Guideline

SNAP is used extensively by the National Geodetic Office (NGO) at LINZ for quality assurance and computation of geodetic co-ordinates.

While SNAP is unsupported by LINZ, the purpose of this document is to provide some guidelines for those creating their own survey control networks.

The content covered in this guideline is limited to GNSS (Global Navigation Satellite System) observations, with CSV (Comma-Separated Values) file examples for a LINZ Order 5 control survey. Information regarding other aspects of SNAP can be found in SNAP **Help | Help**, or by pressing **F1** at any time while using the SNAP package.

Please note: Surveyors with no knowledge of SNAP are still able to provide their untested control networks for LINZ analysis and submission to the Geodetic Database. See the *Guidelines for Simplified Geodetic Control Survey* on the LINZ website:
http://www.linz.govt.nz/geodetic/standards-publications/geodetic-specifications

2.2. Contact Information

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3. Installation

The SNAP package can be downloaded from the LINZ website:

http://www.linz.govt.nz/geodetic/software-downloads/snap

3.1. Downloads

SNAP runs on most recent versions of Microsoft Windows.
Please note the conditions for the use and download of this software before downloading.

3.1.1. SNAP

There are two SNAP .zip files that must be installed to be able to use all the functionality described in this guideline:

- The "*SNAP Suite*", and

- The SNAP add-on package "*LINZ geodetic contractor tools*"

3.1.2. Perl

Some of the utility programs supplied with SNAP require the perl interpreter to be installed. This is can be obtained from the Activestate website: http://www.activestate.com/activeperl


3.2. File Path

The default SNAP file path is:
C:\Program Files\Land Information New Zealand\SNAP

Please note: this may not be the same for your own computer/network


NOTE:

When working on a SNAP adjustment, best practice is to create a new folder in your *local directory*, where all input files (Section 4) are stored. As SNAP will look for files in a local directly before trying the default file path:
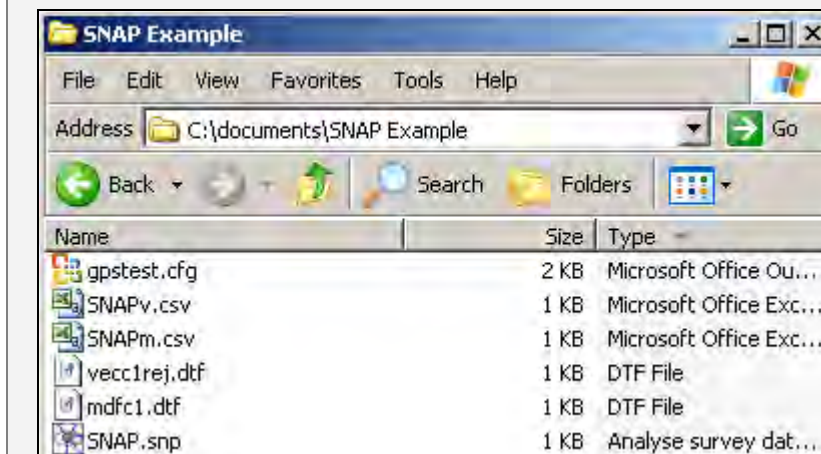
3.3. SNAP Program Window

When opening a new SNAP program, you will be presented with the SNAP Program Window.

Example: SNAP Program Window

Example: SNAP Program Window SNAP.snp
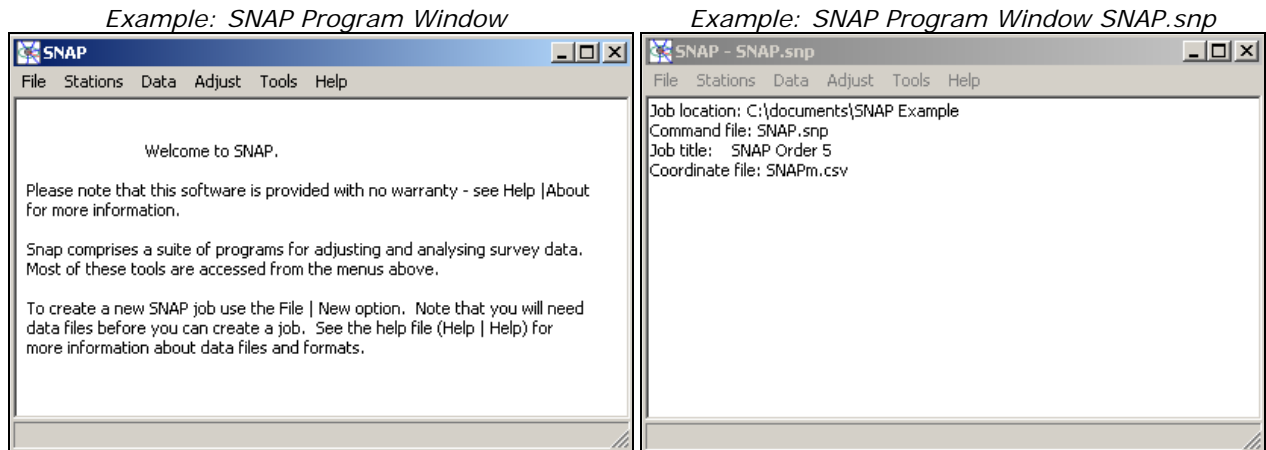
From the SNAP Program Window there are six menu items in a single toolbar: File, Stations, Data, Adjust, Tools and Help.

In this document, instructions for selected functions from the toolbar will be given in the format: **Toolbar Item | Function.**

*Example: selecting the Help Menu - **Help | Help***
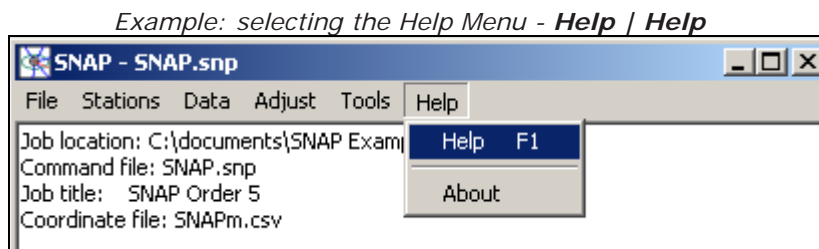
3.4. SNAP Program Overview

Below is a flowchart providing an overview of the SNAP program, including a summary of the inputs and outputs files identified in this document.
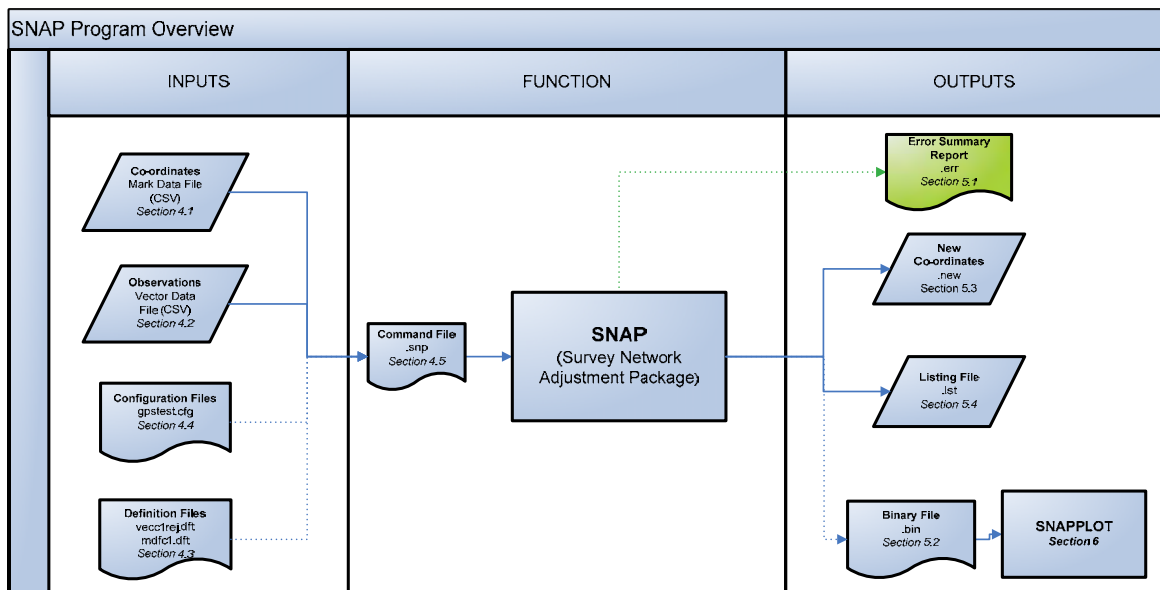
4. Input Files – CSV Format

There are five SNAP input files to be aware of. All SNAP adjustments require one of the following types:

These files should be stored together in a folder in your local directory

a)   SNAP command file (.snp or .cmd)

> **NOTE:**
>
> .cmd is the old command file extension, it has been known to cause conflicts with other Windows programs so has been replaced with .snp
>
> If presented with the old .cmd file extension, this can be manually changed to .snp with no ill effects.

b)   Mark Data File or Co-ordinate File (.csv or .crd)

c)   Vector Data File or Data File (.csv or .dat)

d)   Configuration File (.cfg) – gpstest.cfg

e)   Definition File(s) (.dtf) – vecc1rej.dtf and mdfc1.dtf

> **NOTE:**
>
> vecc1rej.dtf is not supplied in the SNAP downloads. This will need to be created by the user, see Section 4.3.2

Simply speaking, every SNAP adjustment must have a list of co-ordinates, a list of data and file(s) of instructions. SNAP allows co-ordinates and data lists to be supplied in a CSV file format, as well as formats specific to SNAP (.crd and .dat).

This guideline is limited to examples in the CSV format.

One of the benefits of using the CSV file format is that the data is easier to transfer between software packages. For example it may be possible to create a Vector Data File directly from your GNSS processing software.

There are some limitations with the CSV file format. For example, some of the more advanced SNAP functionality is not available. However, this CSV file format is suitable for Order 5 GNSS control observations.

4.1. Mark Data File

This section describes the default Mark Data File as defined by mdfc1.dft (see Definition File(s) Section 4.3.1). The following describes the minimum mark data information required by SNAP.

4.1.1. Creating a Mark Data File

The default Mark Data File CSV should have the following headings:

CODE	MRKS	MRKT	EXMK	DISTRICT	CROD	ORDV1	ORDV2	ORDV3	NAME	ALTN	COMM

CODE* – Geodetic Code (or place holder)

MRKS** – Flag if the mark exists in the Geodetic Database (PEND if No, COMM if Yes)

MRKT** **–** Mark Type

EXMK**– Flag (duplication) if the mark exists in the Geodetic Database (N if No, Y if Yes)

DISTRICT** **–** Land District

CROD – Co-ordinate order (if it has one)

ORDV1* – Latitude (decimal degrees)

ORDV2* – Longitude (decimal degrees)

ORDV3* – Ellipsoidal Height

NAME* - Mark Name

ALTN** – Alternative mark name (if it has one)

COMM – Space for any comments

* denotes field required to be populated

** recommend to be left blank

4.1.2. Automatically Populating Fields

For marks which exist in the Geodetic Database (http://www.linz.govt.nz/geodetic/geodetic-database), the required fields can be automatically populated.

(a)   Create a Mark Data File CSV with the headings as shown in Section 4.1.1

(b)   Add the Geodetic Code of the existing marks under **CODE**

Example: SNAPm.csv with Geodetic Codes

	A	B	C	D	E	F	G	H	I	J	K	L
1	CODE	MRKS	MRKT	EXMK	DISTRICT	CROD	ORDV1	ORDV2	ORDV3	NAME	ALTN	COMM
2	AVLN											
3	BDNC											
4	DEN2											

(c)   Ensure that the Mark Data File is referenced in the Command File (Section 4.5)

(d)   Open SNAP and select **Stations | Update MDFC from GDB**

> **NOTE:**
>
> The Mark Data File will not be able to be updated if it is open in another application (such as Excel).

(e)   The Mark Data File should now be populated

Example: SNAPm.csv automatically populated

	A	B	C	D	E	F	G	H	I	J	K	L
1	CODE	MRKS	MRKT	EXMK	DISTRICT	CROD	ORDV1	ORDV2	ORDV3	NAME	ALTN	COMM
2	AVLN					2k3	-41.1964	174.9329	39.585	Avalon Sound Stage		
3	BDNC					2k4	-41.2459	174.8992	16.146	RM VI SO 35854		
4	DEN2					2k5	-41.2546	174.9164	38.918	IB III DP 69734		

4.1.3. Manually Populating Fields

For marks which do not exist in the Geodetic Database the required fields (CODE, ORDV1, ORDV2, ORDV3 and NAME) must be populated by the user. This is done by simply filling in the fields either manually or copied from your GNSS processing software.

Example: SNAPm.csv completely populated

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	CODE	MRKS	MRKT	EXMK	DISTRICT	CROD	ORDV1	ORDV2	ORDV3	NAME	ALTN	COMM	
2	AVLN					2k3	-41.1964	174.9329	39.585	Avalon Sound Stage			
3	BDNC					2k4	-41.2459	174.8992	16.146	RM VI SO 35854			
4	DEN2					2k5	-41.2546	174.9164	38.918	IB III DP 69734			
5	NEW1					2k6	-41.257	174.916	33.58	PIN SO 654321		new mark near number 42	

(a) **CODE** – your new mark may not have a Geodetic Code, in which case a placeholder can be used (eg "NEW1").

(b) **CROD** – for all new marks use "2k6" (literally: 2000 Order 6). For existing control marks use their current mark order:

CROD Code	Description
2k0	Order 0
2k1	Order 1
2k2	Order 2
2k3	Order 3
2k4	Order 4
2k5	Order 5
2k6	Order 6 or lower

(c) **ORDV1 ORDV2 ORDV3** – for control marks being held fixed in the adjustment (See Section 7.3), the ordinate values must exactly match those in the Geodetic Database. However, for new marks (or marks which are going to be free in the adjustment) these ordinate values can be approximate.

(d)   **NAME** – for existing marks, this should be their existing name, for new marks this should be their name from a CSD (if there is one). In the case where there is no CSD, the mark name should reflect the mark type and perhaps geographical location (eg PIN 1 BENMORE).

(e)   **ALTN –** If the mark has an existing alternative name, this can be entered here, otherwise this field can remain blank.

(f)   **COMM –** This 'comments field' is a free text field where any contextual information and/or notes can be stored. Note: information in the **COMM** field is for information only.

4.2. Vector Data File

This section describes a Vector Data File CSV as defined by vecc1rej.dft (see Definition File(s) Section 4.3.2).

> **NOTE:**
>
> The Definition File vecc1.dft is supplied in with the SNAP suite. However this does not define the **REJECTED** column. Therefore the user is required to create vecc1rej.dft, either from scratch or by modifying the existing vecc1.dft file.

4.2.1. Creating a Vector Data File

REJECTED	FCODE	TCODE	DATE	TIME	DX	DY	DZ	METH	EFAC	COMM

REJECTED – To 'reject' an observation (Section 4.2.2) from the adjustment "Y" should be placed in this column, otherwise it should be left blank.

FCODE* – From Station Geodetic Code (must be the same **CODE** as specified in the Mark Data File, Section 4.1)

TCODE* - To Station Geodetic Code (must be the same **CODE** as specified in the Mark Data File, Section 4.1)

DATE* – Date of observation, in the format: YYYY.MM.DD
    Example: 2012.06.28

TIME* – Start time of the observation (NZST), in the format: HH.MM
    Example: 09.30 or 9.30

> **NOTE:**
>
> It is important to ensure that and **DATE** and **TIME** are in the correct format, with the specified number of characters.
>
> Leading and trailing zeros (for example, in the case 09.30) may be lost each time a .csv file is opened in Excel. While SNAP will work without leading zeroes, it will report an error where trailing zeroes are lost (9.30 is fine but 9.3 is not).

DX* – vector component Delta X (geocentric, not the same as the change in easting)

DY* - vector component Delta Y (geocentric, not the same as the change in northing)

DZ* – vector component Delta Z (geocentric, not the same as the change in up)

> **NOTE:**
>
> GNSS data should be captured as the vector differences between two receivers. This is expressed as X, Y, and Z components in a geocentric reference frame. The best way to capture this information is directly from your GNSS processing software.
>
> SNAP is **NOT** expecting (and cannot accept) east, north and up (E, N, U) vector components. This will cause significant errors in the adjustment

METH* – Code for method used to observe the GNSS vector – This is used to assign errors in SNAP (these errors are defined in the Vector Definition File, Section 4.3.2)

METH Code	Description
CORS1	Vector derived from static or fast static data, where at least one mark is a CORS site.
STAT1	Vector derived from static or fast static data.
RTK1	Vector derived from RTK or PPK data.
NRTK1	Vector derived from Network RTK data.

EFAC – This is the field where an error factor could be applied.

COMM - This "comments field" is a free text field where any contextual information and/or notes can be stored. Please Note: Information in the **COMM** field is for information only.

* denotes fields required to be populated

Example: SNAPv.csv

4.2.2. Rejecting Vectors

To reject a vector in the CSV format you add a "Y" to the column of the vectors that you wish to reject.

Example: SNAPv.csv with a vector rejected

4.3. Definition Files

As the SNAP program is expecting to receive .crd and .dat input files (see Section 4), when using the CSV file format to input data you must specify the data supplied in each column. The following definition files are required by this guideline:

a) mdfc1.dft – to define the mark data file, and

b) vecc1rej.dft – to define for the vector data file

> **NOTE:**
>
> The definition files are able to be edited by the snap user. Once edited LINZ recommends renaming the definition files to make it clear they have been changed.

4.3.1. Definition – Mark Data File

Example: mdfc1.dft

```
format_name LINZ geodetic contract mark data file
format CSV
required_columns code ordv1 ordv2 ordv3

code @CODE
name @NAME
coordinate_system $crdsys default "NZGD2000"
height_type "ellipsoidal"
longitude @ORDV2
latitude @ORDV1
height @ORDV3
classification Order CROD
classification_columns MRKS MRKT EXMK DISTRICT ALTN COMM
```

4.3.2. Definition – Vector Data File

Example: vecc1rej.dft

```
format_name LINZ geodetic contract vector data file
FORMAT CSV HEADER=Y
required_columns FCODE TCODE DATE TIME DX DY DZ

OBSERVATION
TYPE "GB"
REJECTED @REJECTED
INSTRUMENT_STATION @FCODE
TARGET_STATION @TCODE
DATETIME @DATE " " @TIME
DATETIME_FORMAT YMDhm
VALUE @DX " " @DY " " @DZ
ERROR METHOD_ERROR(@METH)
VECTOR_ERROR_TYPE calculated
ERROR_FACTOR @EFAC DEFAULT 1.0
CLASSIFICATION METHOD @METH
NOTE @COMM
END_OBSERVATION

LOOKUP METHOD_ERROR
CORS1 3 3 6 mm 0.4 0.4 0.8 ppm
STAT1 4 4 8 mm 0.5 0.5 1 ppm
RTK1 8 8 12 mm 1 1 1 ppm
NRTK1 8 8 12 mm 0.4 0.4 0.8 ppm
default 8 8 12 mm 1 1 1 ppm
END_LOOKUP
```

4.4. Configuration Files

Many commands in SNAP are entered in the Command File (Section 4.5). However, these commands will need to be entered every time you create a new Command File. Configuration Files can be used to run commands that you wish to apply every time you run SNAP, while the Command File contains commands specific to the adjustment.

> **NOTE:**
>
> Configuration files cannot contain commands specific to an adjustment. For example they cannot specify data files, or select fixed stations.

SNAP may use several configuration files when running an adjustment. However, the file that is of most interest to the standard user is gpstest.cfg.

4.4.1. gpstest.cfg

gpstest.cfg is used to define the specifications that each order will be tested against. The file provided with SNAP tests against the *Standard for tiers, classes and orders of LINZ data* (LINZS25006), 21 September 2009.

Example: gpstest.cfg

```
! Configuration file for testing GPS surveys against OSG standards.
! Adjustment mode

mode 3d adjustment

! Residual flag significance

error_type apriori
flag_significance 95 maximum 95

! Accuracy specifications for various orders
! The absolute values specified here assume that all stations of a better order than that being tested are fixed
specification order_2 confidence 95% horizontal 3mm 1ppm 70mm_abs vertical 3mm 3ppm 230mm_abs
specification order_3 confidence 95% horizontal 10mm 3ppm 50mm_abs vertical 10mm 10ppm 135mm_abs
specification order_4 confidence 95% horizontal 10mm 10ppm 50mm_abs vertical 10mm 50ppm 135mm_abs
specification order_5 confidence 95% horizontal 10mm 50ppm 70mm_abs vertical 20mm 100ppm 150mm_abs

! Accuracy specifications for various orders
! The absolute values specified here assume that all stations of order 5 and better are fixed
specification order_6 confidence 95% horizontal 30mm 150ppm 70mm_abs
specification order_7 confidence 95% horizontal 60mm 150ppm 150mm_abs
specification order_8 confidence 95% horizontal 300mm 600ppm 480mm_abs
specification order_9 confidence 95% horizontal 1000mm 3000ppm 5000mm_abs
specification order_10 confidence 95% horizontal 3000mm 10000ppm 20000mm_abs
specification order_11 confidence 95% horizontal 10000mm 30000ppm 50000mm_abs


! Output options

spec_test_options list_fail

list no_command_file
list no_file_summary
list no_input_data
list no_problem_definition
list no_iteration_summary
list no_observation_equations
list no_station_adjustments
list solution_summary
list station_coordinates
list no_floated_stations
list no_reference_frames
list no_parameters
list residuals
list error_summary
list worst_residuals

list no_form_feeds
list no_notes
```

> **NOTE:**
>
> When evaluating the result of your adjustment, you must be sure that you have used the "correct" values in the gpstest.cfg file.
>
> For example: if you had edited the file to test some non-LINZ specifications, you should remember to change this back again for other adjustments.

4.5. Command File

The Command File instructs SNAP what to do. It also defines the input and output files. SNAP Command Files use the extension .snp

As a minimum the Command File should have:

a)   The title of the job, on line 1

b)   A reference to the Mark Data File (Section 4.1), and its Definition File (Section 4.3.1)

c)   A reference to the Vector Data File (Section 4.2), and its Definition File (Section 4.3.2)

d)   A reference to the gpstest.cfg, Configuration File (Section 4.4.1), and the specification test to be run

e)   At least one fixed station

Example: SNAP.snp Command File – 3 stations fixed

```
title SNAP Order 5

coordinate_file SNAPm.csv csv format=mdfc1

data_file SNAPv.csv csv format=vecc1rej

configuration gpstest
test_specification order_5 all

!Minimally Constrained Fixed Station:
!fix AVLN

!Constrained Fixed Stations:
fix AVLN WGTN BDNC
```
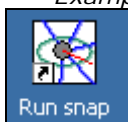
4.5.1. Create a Command File

To create a Command File, you can either create a text file on a computer with SNAP installed and change the extension from .txt to .snp,
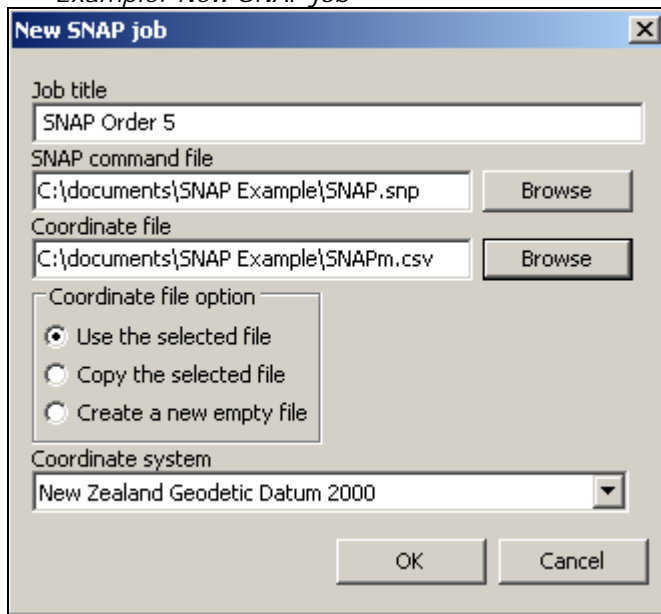
Or

a)   Double clip the "Run snap" icon on your desktop, or open the program "Run SNAP" and from the snap program window, select **File | New**

Example: Run snap icon

b) Complete the "New SNAP job" form, browsing to the folder where the new Command File and the Mark Details File will be found.
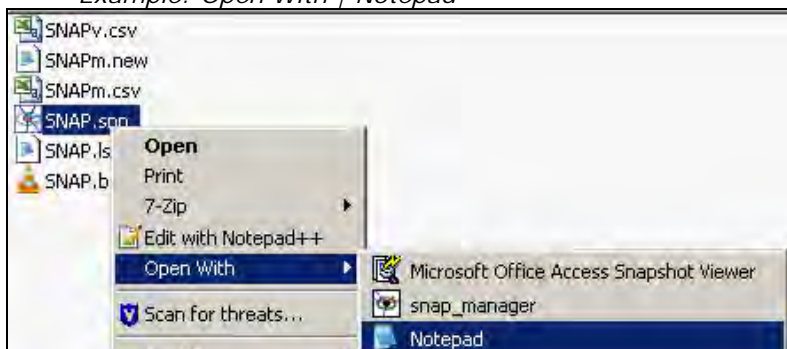
Example: New SNAP job

4.5.2. Edit a Command File

To edit a Command File, you can right click on the .snp and select **Open with | "***text editor***"** (such as Notepad)
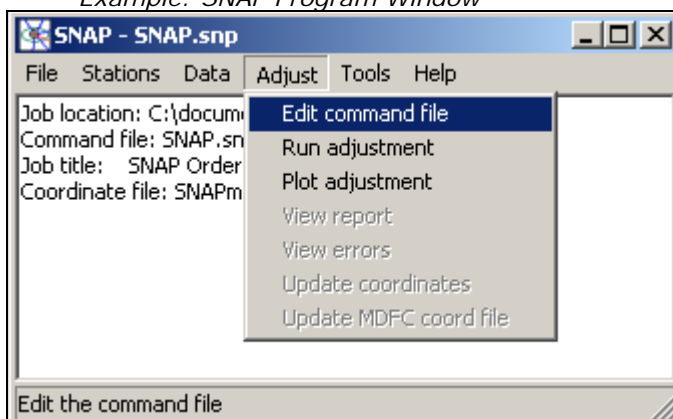
Example: Open With | Notepad

Or,

From the SNAP program window, select **Adjust| Edit command file**

Example: SNAP Program Window

4.5.2.1. Exclude Lines in SNAP

In SNAP specific input files (such as the Command File), each line is considered as a line of code. However, sometimes we have additional information in the SNAP files which is either not code, or is code we do not wish SNAP to run.

To indicate code that SNAP should not run, we use the "!" symbol at the start of a row. This will exclude that line. This is commonly required when we are changing fixed stations between the minimally constrained (Section 7.2) and constrained (Section 7.3) adjustments.

> **NOTE:**
>
> The title text information "Minimally Constrained Fixed Station:" and "Constrained Fixed Stations:" are for information only and not part of the code and so have the "!" at the start of the line, to exclude them.

In Example 1 below, the station AVLN is fixed (this is a minimally constrained adjustment), while the constrained adjustment stations and the heading information has been excluded from the code.

Example 1

```
!Minimally Constrained Fixed Station:
fix AVLN

!Constrained Fixed Stations:
!fix AVLN WGTN BDNC
```

In Example 2, a constrained adjustment is being run, but only the stations ALVN and WGTN are held fixed, BDNC is after the "!" and so has been excluded.

Example 2

```
!Minimally Constrained Fixed Station:
!fix AVLN

!Constrained Fixed Stations:
fix AVLN WGTN !BDNC
```

5. Output Files

Based on the Command File (Section 4.5) and Configuration File (Section 4.4) SNAP will provide output files. This section explains the files which are supplied when using the SNAP defaults.

To create SNAP output files the SNAP adjustment must be 'run'.

To 'run' a SNAP adjustment select: **Adjust | Run adjustment**

A second *Snap adjustment* window will open, which indicates the adjustment progress.

> **NOTE:**
>
> An adjustment comprised of only a few marks/observations will complete in a matter of seconds. Adjustments that contain hundreds of marks (therefore possibly thousands of observations) may take several minutes to run.

At the completion of the adjustment the *SNAP adjustment* window must be closed, by hitting the "Close" button. The information provided in the *Snap adjustment* window, is available in the Listing File (See Section 5.4)

Example: Snap Adjustment window
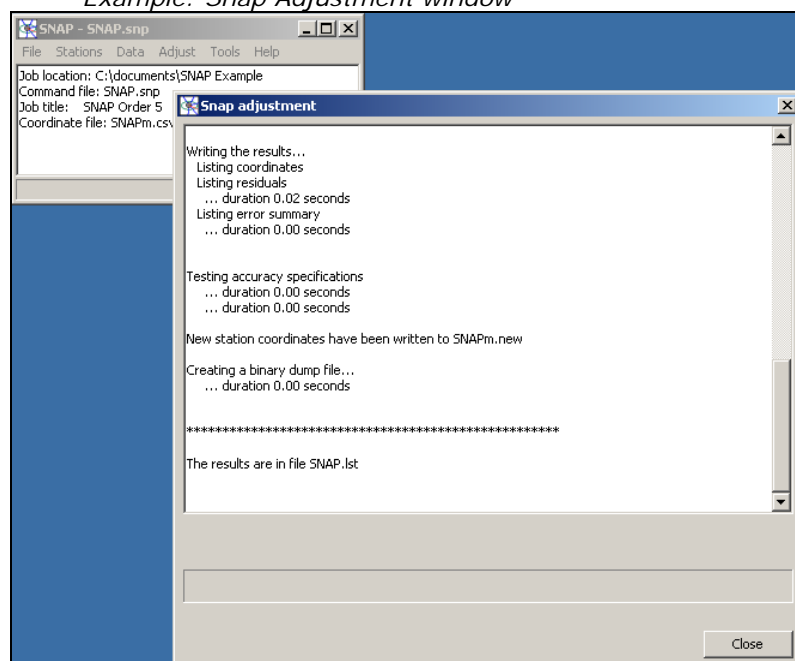
5.1. Error Summary Report

If there is an error in the Mark Data File (Section 4.1), Vector Data File (Section 4.2) or Command File (Section 4.5) an error summary report will be created (in the same folder as the Command File) with the file extension .err. Any error in the error summary report needs to be resolved.

> **NOTE:**
>
> When SNAP runs without error, no error summary report will be created and any previous report will be deleted.

The error summary report will report on the:

a)   type of error,

b)   line the error is on, and

c)   the file which the error is occurring in

Example: *SNAP.err FCODE incorrect*

```
================================================================================
                                                        16-NOV-2012 13:20:27

                              ERROR SUMMARY

================================================================================

Error: From station code is invalid
       Line: 16   File: SNAPv.csv

Error: 1 errors reported reading the data files
```

In the above example the Vector Data File is incorrect, as the "From station" (FCODE) on Line 16 is either:

• not specified in the Mark Data File and/or

• incorrect in the Vector Data File

Example: SNAP.err singularity

```
================================================================================
                                                        16-NOV-2012 13:25:46

                              ERROR SUMMARY

================================================================================

Error: Normal equations are singular
       A singularity was detected at north coordinate of station WGTN
```

In the example above, SNAP has been unable to calculate a co-ordinate of at least one station in the adjustment. There can be a number of causes for this error, such as having no fixed stations or incorrect approximate co-ordinates. As this error is non-specific, SNAP has been unable to identify the incorrect file or line number where the error has occurred.

More information about errors and possible resolutions can be found in **Help | Help**

5.2. Binary File

One of the outputs from the SNAP adjustment is a Binary File .bin, which will appear in the same folder as the Command File.

The Binary File is used by programs such as SNAPPLOT and Configuration Files such as gpstest.cfg to analyse the results of the adjustment.

5.3. New Co-ordinate File

The new co-ordinates which are the result of the SNAP adjustment are exported in a text file .new, this will appear in the same folder as the Command File.

The new co-ordinates are in terms of NZGD2000 and are in decimal degrees.

> **NOTE:**
>
> The "new co-ordinates" of marks held fixed in the SNAP adjustment will be unchanged from those provided in the input Mark Data File.

Example: SNAPm.new

```
Read from SNAPm.csv
NZGD2000
options ellipsoidal_heights no_deflections no_geoid_heights degrees c=Order c=MRKS c=MRKT c=EXMK c=DISTRICT c=ALTN c=COMM
! Updated by SNAP version 2.3.63 at 16-NOV-2012 13:46:38

!Code      Latitude           Longitude        Ell.Hgt Order MRKS  MRKT  EXMK  DISTRICT ALTN  COMM  Name
AVLN      -41.19644089000    174.93286040000   39.5850 2k3   -     -     -     -        -           Avalon Sound Stage
BDNC      -41.24593771925    174.89915976068   16.0750 2k4   -     -     -     -        -           RM VI SO 35854
DEN2      -41.25460117197    174.91640909963   38.8386 2k5   -     -     -     -        -           IB III DP 69734
NEW1      -41.25752077350    174.91588563500   33.1142 2k6   -     -     -     -        -           PIN SO 654321
WGTN      -41.32345695071    174.80589413242   26.0617 2k0   -     -     -     -        -           WELLINGTON AIRPORT
```

5.4. Listing File

The Listing File provides a summary of the adjustment results, including information regarding the quality of the adjustment. The .lst file will appear in the same folder as the SNAP command file.

Additional detail on how to evaluate the listing file is provided in Section 7, Error Analysis and Network Adjustment.

Some points of interest in the listing file are:

- The Solution Summary
    - Degrees of Freedom
    - Standard Error of Unit Weight (SEUW)
- Observation Residuals
    - Residual on each component (E,N,U)
    - Standardised residual on each component (E,N,U)
- Accuracy Specification Tests
    - Absolute accuracy tests
    - Relative accuracy tests

6. SNAPPLOT

SNAPPLOT is a program that allows the visualisation of adjustment data.

Once an adjustment has been run (**Adjustment | Run adjustment**) in the SNAP program, without generating an error summary report (Section 5.1), SNAPPLOT can be opened:
**Adjustment | Plot Adjustment**

> **NOTE:**
>
> Only one instance of SNAPPLOT can be open at any one time, and the SNAP adjustment cannot be "run" again until the SNAPPLOT window has been closed. Failing to close SNAPPLOT before running the adjustment will result in the following error in the SNAP program window:
>
> *Unable to create binary file*

6.1. SNAPPLOT Features

The purpose of SNAPPLOT is to view the adjustment. You are unable to edit the input files (Section 4) or change the adjustment outputs (Section 5)

Example: SNAP.snp SNAPPLOT
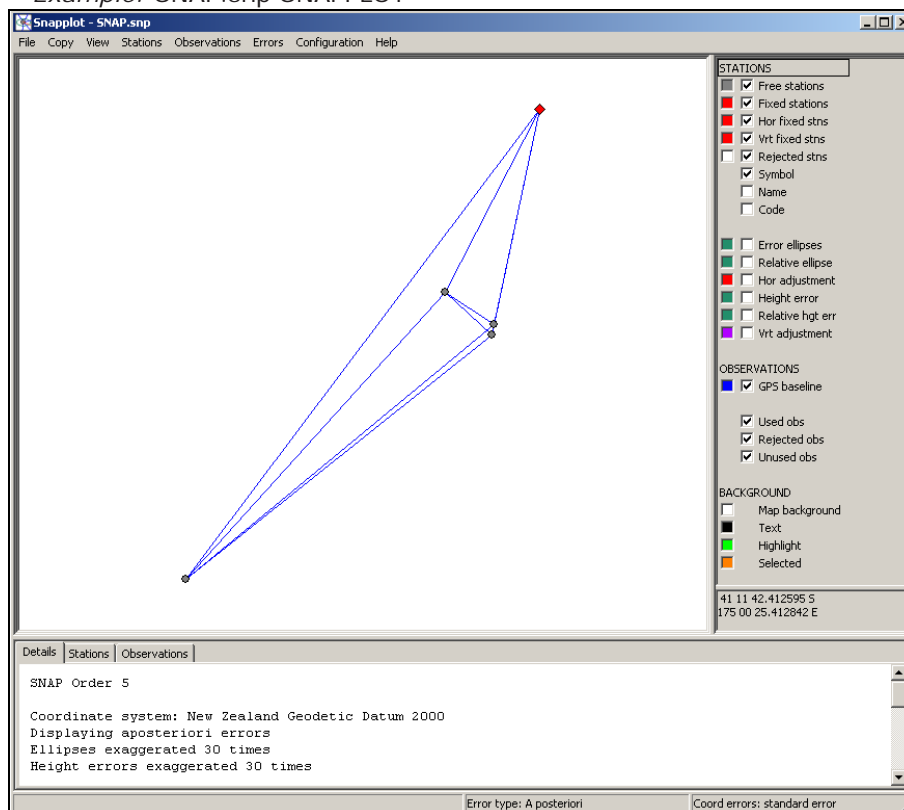
While you are unable to modify the data in SNAPPLOT, you are able to modify how and what is presented.

The following is a brief description of the SNAPPLOT program. More information can be found in **Help | Help**

6.1.1. SNAPPLOT Toolbar

As with the Program Window (Section 3.3) most of the interactions in SNAPPLOT are done via the toolbar. There are eight menu items in the toolbar: File, Copy, View, Stations, Observations, Errors, Configuration and Help.

File, Copy, View and Help are similar to those in other applications, while the configuration menu is largely unused by general SNAP users.
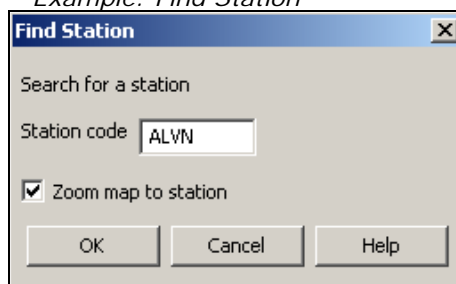
6.1.1.1. Stations Menu

- The "Colour coding" function will colour the stations based on columns from the Mark Data File (Section 4.1), such as mark order. By default stations will be displayed in terms of their usage: Free, Fixed or Rejected.

- "Highlight Stations" and "Hide Stations" can be a useful tool for identifying stations that meet (or fail to meet) certain qualifications, such as the mark status or accuracy within a threshold.

Example: Highlight stations – By status, Fixed horizontally
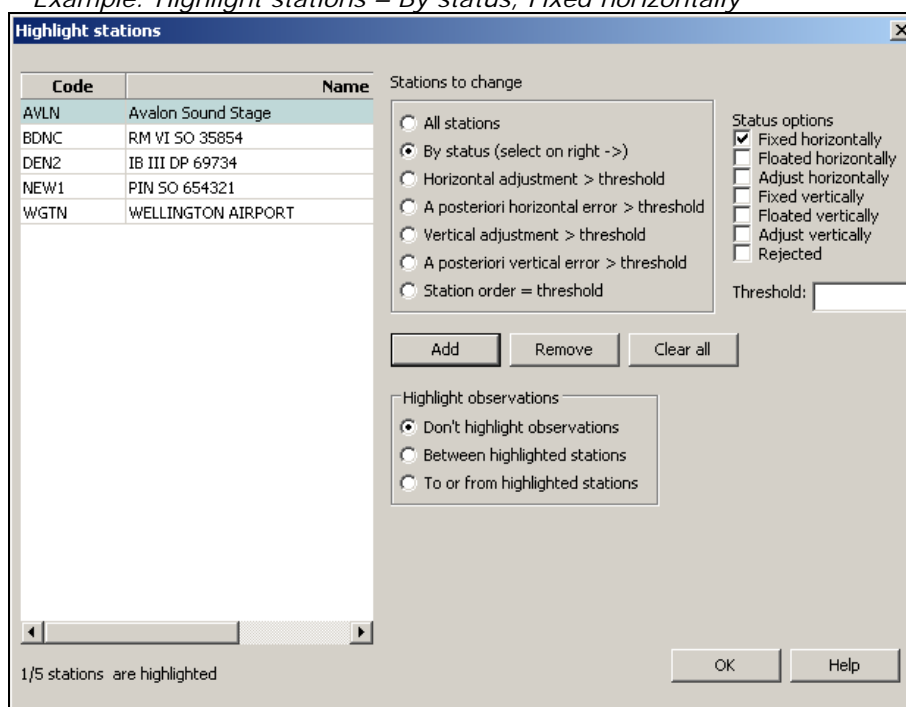
- "Find Station" (**or Ctrl-F**), will highlight and/or zoom to an individual mark. In the Find Station window, enter the code (as specified in the Mark Data File, Section 4.1) of the mark that you are trying to locate.

Example: Find Station

6.1.1.2. Observations Menu

- The "Colour coding" function will colour the observations based on the adjustment results and/or columns from the Vector Data File (Section 4.1), such as observation

method. By default stations will be displayed in terms of their data type – in this example all observations are GNSS baselines.

- "Highlight Observations" can be a useful tool for identifying observations that meet (or fail to meet) certain qualifications, such as observations with low redundancy.

Example: Highlight observations – by redundancy factor less than threshold
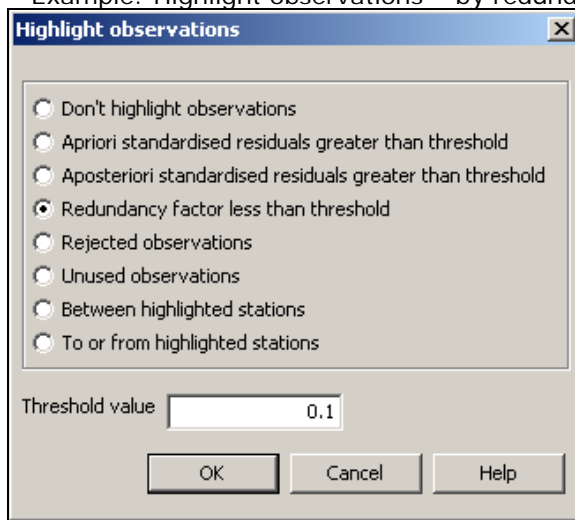
- "Display options…" allows you to determine how multiple observations of the same line are displayed.
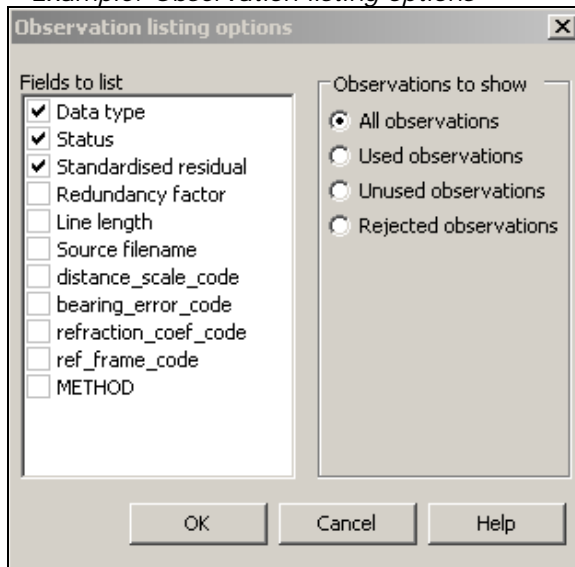
Example: Observation display options
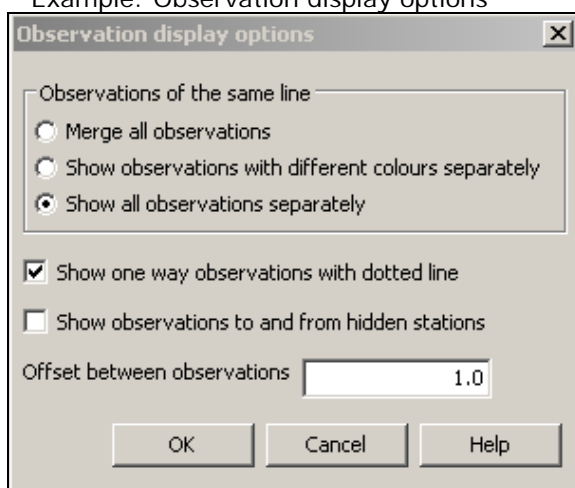
- "Listing options…" This function allows you to modify the information which is included in the Observations tab (Section 6.1.4).

> **NOTE:**
>
> Data type, status and standardised residual are defaults – but it may be useful to turn the "Redundancy factor" field on.
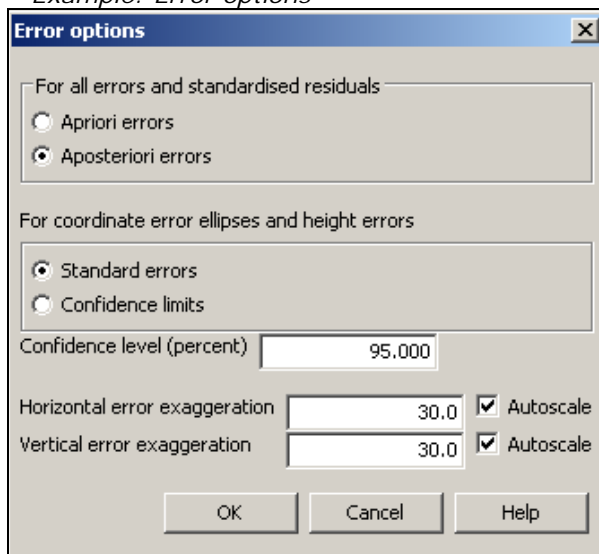
Example: Observation listing options

6.1.1.3. Errors Menu

- There is one function under the Errors menu "Error options…" This function is used to determine the type of error and how they are displayed. This includes setting apriori or aposteriori errors and the error exaggeration.

Example: Error options

6.1.2. SNAPPLOT Map

The adjustment is displayed in the centre of the SNAPPLOT application.

This map is interactive:

- To zoom in to an area, click and drag the left mouse button.

- To zoom out to the last extent, click right mouse button.

- To pan, hold down the "Shift" key use the left mouse button to drag.

- To move a station for clarity, hold down "Ctrl" + "Shift" and left click and drag the station you want to move (this can be undone from **Stations | Ignore station offsets)**.

- To find information about a station, click on the station symbol – this information is then shown in the Details tab (Section 6.1.4.1)

- To find information about an observation, click on the observation line – this information is then shown in the Details tab (Section 6.1.4.1)

- To find out information between stations, double click the first station and single click the second station (left click in the map window to clear this selection) – this information is then shown in the Details tab (Section 6.1.4.1)

6.1.3. SNAPPLOT Key

The SNAPPLOT key window is used to select colours for each feature on the map and to select which features are displayed. Each feature has an associated colour and a checkbox.
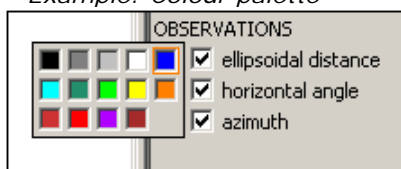
Example: SNAPPLOT Key (part)
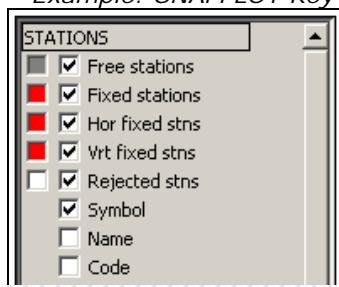
Items displayed on the map can be changed using the "Colour coding…" feature **Stations | Colour coding** (Section 6.1.1.1) or **Observations | Colour coding** (Section 6.1.1.2).

To change the colour of a feature:

- Position your mouse over the colour box, and hold down the left mouse button, (this will give display a colour palette).

- Drag the mouse to a new colour, and release the button to select it.

Example: Colour palette

6.1.4. SNAPPLOT Tabs

At the bottom of the SNAPPLOT window there are three tabs that provide summary information about the adjustment. They are Details, Stations and Observations.

Example: SNAPPLOT tabs
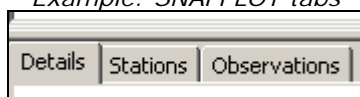
6.1.4.1. Details Tab

When no stations or observations are highlighted (Section 6.1.2) the Details tab shows general information regarding the adjustment, such as the error exaggeration, the number of stations the Standard Error of Unit Weight, etc.

When a station or an observation has been selected (Section 6.1.2) more specific information is displayed in the Details tab

Example: Details tab showing a selected observation

Blue hyperlinks can be selected to find more information regarding an individual observation or station.

Example: Details tab after selecting a GNSS baseline

6.1.4.2. Stations Tab

The Stations tab shows a list of station information, as contained in the Mark Data File (Section 4.1).

Example: Stations tab (part)

Code	Latitude	Longitude	Height	Status	Hor.Err	Vrt.Err	Hor.Adj	Vrt.Adj	Order	MRKS	
AVLN	41 11 47.187204 S	74 55 58.297440 E	39.585	Fix	0.000	0.000	0.000	0.000	2k3	-	-
BDNC	41 14 45.375817 S	74 53 56.975084 E	16.072	Adjust HV	0.003	0.007	0.013	-0.074	2k4	-	-
DEN2	41 15 16.564230 S	74 54 59.072738 E	38.837	Adjust HV	0.003	0.006	0.029	-0.081	2k5	-	-

By clicking on a row, the station will be highlighted in the SNAPPLOT map (Section 6.1.2) the Details tab will then display the highlighted station's specific information. '**Shift + left click**' on a row, will move the SNAPPLOT map view to the selected station.

6.1.4.3. Observations Tab

By default the Observations tab shows, the From Code, To Code, Observation type (GB – GNSS Baseline) and standardised residual. However, more information can be shown using **Observations | Listing options** (Section 6.1.1.2).

> **NOTE:**
>
> It is often useful to add the "Redundancy factor" column.

Example: Observations tab with redundancy factor added

From	To	Type	Status	Std.res	Redundancy
AVLN	NEW1	GB		1.63	0.784
AVLN	NEW1	GB		1.39	0.784
BDNC	DEN2	GB		1.19	0.822
BDNC	WGTN	GB		1.19	0.831

(Tabs shown above the table: Details | Stations | Observations)

By clicking on a row the Observations tab, the vector will become highlighted in the SNAPPLOT Map (Section 6.1.2) the Details tab will then display the highlighted observation's specific information. '**Shift + left click**' on a row, will move the SNAPPLOT Map view to the extent of the selected observation.

7. Error Analysis and Network Adjustment

SNAP uses a statistical approach called Least Squares to evaluate the data and distribute errors.

However, in order for the adjustment results to be reasonable all the data in the adjustment must be processed so that:

1. all gross and systematic errors are eliminated and

2. random errors are minimised.

7.1. Errors and Least Squares

In every observation there is an element of error, no matter what method you use to make the measurement. However, some methods are more accurate than others.

For example, if you were to measure a line:

1. You might pace it out and say it is 50m long

2. With a cloth tape, you might say it is 48.2m long

3. If you were measure it with a total station – you might say it is 48.187m long

   a) The second time you set-up over the same line you might get a reading of 48.188m long

   b) If, when you set up, you were not plumb over the mark you might say it was 48.194m long

   c) If there was a calibration error in your instrument, you might say it is 48.175m long

   d) Or you might get the wrong line completely and say it is 67.782m long

7.1.1. Expected Errors

In situations 1, 2, 3 above, all of the measurements are correct. However, the precision of the measurement is influenced by the observation method.

1 ~ metres

2 ~ decimetres

3 ~ millimetres

In these cases, we should set the errors in SNAP to reflect the expected error of the method we are using (GNSS errors are specified in the Definition File, Section 4.3.2)

SNAP would use these estimates to distribute errors throughout the adjustment, placing more of the error in our paced observations and less in the total station observations.

7.1.1.1. Random Errors

Random errors are fluctuations in the measurement due to the precision limitations of the device or method being used.

If you take a measurement using the same method, statistically speaking you are likely to get slight variations in the values. For example 3a) 48.188m is a slight variation from 3) 48.187m. If you are were to measure the line again the third reading may be 48.185m.

The effects of random errors can be minimised by making multiple independent observations. For example, by making multiple measurements, we can conclude it is more likely that the *true* length of the line is closer to 48.187m than 48.185m.

SNAP will distribute random errors throughout the adjustment. The more independent observations there are in the adjustment, the better SNAP can determine how these errors should be distributed.

> **NOTE:**
>
> SNAP assumes that all observations are independent. Therefore repeat observations which are not independent should not be added to the adjustment – these duplicated lines will bias the results.

7.1.2. Gross Errors and Systematic Errors

All gross and systematic errors must be removed from a SNAP adjustment, otherwise SNAP will distribute these errors throughout the adjustment, when usually they only relate to a small subset of marks or observations. Erroneous observation(s) should be rejected from the adjustment.

7.1.2.1. Gross Errors

Not being set up correctly over the mark 3 b) is an example of a gross error. This could be detected by taking multiple independent observations at the same mark. However, more than two independent observations may be required to identify which observation is erroneous.

Sometimes it is possible that when taking a measurement you observe the wrong mark 3d). It is highly unlikely that SNAP would flag this error, unless it was one of the fixed marks. If the same incorrect mark is observed, independent sessions would not identify this error. Sound office and field checks are required to ensure that errors such as this do not occur.

7.1.2.2. Systematic Errors

Systematic errors can be difficult to detect as all the data can be affected, even observations that are considered to be independent can be in error by the same amount.

An example of a systematic error would be an uncalibrated instrument 3c), or mismeasurement of a GNSS base-station antenna.

Unless combining datasets (which are completely independent), or have a large proportion of fixed control, it is unlikely that a small systematic error would be picked up in SNAP. Instead sound office and/or field procedures are required to ensure that such errors do not occur.

Once identified, SNAP has some capacity to account for systematic errors such as scale errors and bearing swings. However, it is better if the observation method is corrected to ensure that these types of systematic errors do not occur.

7.1.3. Common Sources of Error

The following are common sources of error which should be independently checked and recorded:

        a)   Antenna heights

        b)   Antenna reference points

        c)   Antenna phase centre models

d) Any spacers are correctly measured and recorded

e) Location and/or description of the mark

f) Equipment set up and mark reference point

g) Sources of multipath (poor observation conditions)

7.1.4. GNSS Observation Errors

By analysing geodetic control datasets and GNSS equipment specifications LINZ has determined a standard set of GNSS Observation Errors for different observational methods **METH**, used in the Vector Data File (Section 4.2). The values associated with these errors (constant and proportional) are defined in the Vector Definition File: *vecc1rej.dft* (Section 4.3.2) and are displayed in the table below:

METH Code	Description	Standard Error Constant Component			Standard Error Proportional Component		
		East mm	North mm	Up mm	East ppm	North ppm	Up ppm
CORS1	Vector derived from static or fast static GNSS data where at least one mark is a Continuously Operating Reference Station (CORS)	3	3	6	0.4	0.4	0.8
STAT1	Vector derived from static or fast static GNSS data	4	4	8	0.5	0.5	1
RTK1	Vector derived from RTK, PPK or Network RTK data	8	8	12	1	1	1
NRTK1	Vector derived from Network RTK data	8	8	12	0.4	0.4	0.8

Users who have a better estimate of the Observational Errors of their particular make and model of GNSS receiver and antenna (such as equipment specifications from the manufacturer) may wish to create their own **METH** value, such as:

RTK2	*Vector derived from 'Make/Model' RTK data*	'7'	'7'	'8'	'1.1'	'1.1'	'1.2'

> **NOTE:**
>
> Once a definition file has been edited by a user LINZ recommends renaming the definition files to make it clear they have been changed.

7.1.5. Error Factors

Error Factors can be used to scale the Observation Errors (Section 7.1.4) for an individual vector, in order to provide a better estimate of the error for that vector.

While we may be confident of the performance of GNSS equipment in favourable operating environments (the Observation Errors values reflect this), there may be vectors in the adjustment which were observed in less than ideal conditions: poor satellite configuration, strong multipath environment, short occupation time etc. For these observations we may wish to scale the errors, down-weighting them so that SNAP distributes more error to these vectors.

Error Factors are applied in the EFAC column of the Vector Data File (Section 4.2). Error Factors should be shown to two decimal places. It is also good practice to leave a comment in the **COMM** section indicating why the error factor was applied.

- An Error Factor of 1.00 is the same (100% of) as the Observation Error.

- An Error Factor of 2.00 is twice (200% of) the Observation Error.

Example: SNAPv.csv Error Factor applied (down-weight).

	A	B	C	D	E	F	G	H	I	J	K	L
1	REJECTE[	FCODE	TCODE	DATE	TIME	DX	DY	DZ	METH	EFAC	COMM	
2		AVLN	DEN2	2012.06.28	2.28	4362.693	997.39	-4857.64	CORS1		1.1	Large deciduous tree
3		AVLN	DEN2	2012.06.28	1.32	4362.692	997.386	-4857.65	CORS1		1.1	Large deciduous tree
4		AVLN	NEW1	2012.06.28	3.54	4583.863	1021.758	-5097.62	CORS1			
5		AVLN	NEW1	2012.06.28	3.27	4583.832	1021.75	-5097.64	CORS1			
6		BDNC	WGTN	2012.06.28	1.49	6350.991	7272.605	-6475.97	CORS1			

Similarly, in some situations, such as an extremely long (24 hour) occupation etc, there may be cause to up-weight an individual vector so that less error is distributed on this observation.

- An Error Factor of 0.50 is half (50% of) the Observation Error.

Example: SNAPv.csv Error Factor applied (up-weight).

	A	B	C	D	E	F	G	H	I	J	K	L
1	REJECTE[	FCODE	TCODE	DATE	TIME	DX	DY	DZ	METH	EFAC	COMM	
2		AVLN	DEN2	2012.06.28	2.28	4362.693	997.39	-4857.64	CORS1			
3		AVLN	DEN2	2012.06.28	1.32	4362.692	997.386	-4857.65	CORS1			
4		AVLN	NEW1	2012.06.28	3.54	4583.863	1021.758	-5097.62	CORS1		0.95	20 hour occupation
5		AVLN	NEW1	2012.06.28	3.27	4583.832	1021.75	-5097.64	CORS1			

NOTE:

Error Factors must be applied with caution, as when applied without good cause they may hide gross errors present in the adjustment.

However, in some small networks, with few degrees of freedom, it may be impossible to have a SEUW close to 1 (in the minimally constrained adjustment, Section 7.2) without applying an Error Factor on some or all vectors.

7.2. Minimally Constrained Adjustment

The first test is to check for gross errors. This is done by running a minimally constrained adjustment – where only one mark is held fixed.

NOTE:

The purpose of the minimally constrained adjustment is to ensure that the dataset is internally consistent.

It is not influenced by errors (if they exist) in the control co-ordinates.

The general process for running the minimally constrained adjustment is as follows:

a) Ensure that one (control) station is held fixed in the Command File (Section 4.5)

b) Check the correct errors are assigned to each observation (See **METH**, Section 4.2.1)

c) Ensure that the gpstest.cfg file is referenced in the command file, and the values are correct (Section 4.4.1)

d) Run the adjustment

e) Check that the Standard Error of Unit Weight (SUEW) is no greater than 1.1. This is in the Solution Summary section of the listing File (Section 5.4)

> **NOTE:**
>
> A SEUW of more than 1.1 *may* indicate that either:
>
> - there is an error in one (or more) of the vectors OR
>
> - the estimated errors are incorrect (see Sections 7.1.4 and 7.1.5)

f) Check any observations and baseline components (Observation Residuals section of the listing file, Section 5.4) which have been flagged as outliers (???)(Section 7.2.1)

> **NOTE:**
>
> An outlier flag (???) on baseline components may indicate that either:
>
> - There is an error in one (or more) of the vectors OR
>
> - Estimated errors are over-optimistic based on the data quality (see Sections 7.1.4 and 7.1.5)

g) Reject (Section 4.2.2) or correct/reprocess any erroneous vectors

h) Repeat, until the SEUW is close to 1 and no baseline components are triple flagged.

> **NOTE:**
>
> Depending on the size of the adjustment, number of degrees of freedom etc "close to 1" may be more or less achievable.
>
> *As a rule of thumb is "close to 1" is:*
>
> - *No more than 1.1*
> - *No less than 0.9*

7.2.1. Observation Accuracy Test

Observation accuracy is only checked in a minimally constrained adjustment.

At this stage we look at the residuals and standardised residuals of vectors and their baseline components to identify and/or understand the sources of error in the adjustment.

Below is an example of a vector (BDNC to NEW1), which has been flagged as an outlier (???):

- We see that the easting component has a standardised residual of 1.66, northing 1.36, up 4.33 and overall the vector has a standardised residual 2.79.

- The easting component has a residual of -6mm, northing -5mm, up -30mm and overall the vector has a residual of 31mm.

That is to say, the largest contribution to the error in this vector is the up component.

Example: Vector BDNC to NEW1, flagged as an outlier (???)

```
From  To    Type    Value      +/-      Calc       +/-      Res      +/-      S.R.
                    X,Y,Z               X,Y,Z               E,N,U

BDNC  NEW1  GB       707.702   0.007      707.676   0.004   -0.006   0.003    1.66
                   -1470.483   0.004    -1470.486   0.002   -0.005   0.003    1.36
                    -978.368   0.006     -978.384   0.003   -0.030   0.007    4.33   ???
                    1902.726             1902.727            0.031            2.79   ???
```

At this stage we might check other vectors between the same two stations. In the example below is a second vector between the same stations (BDNC to NEW1).

The second vector has not been flagged. However, its largest residual is also in the up component +20mm.

- Between the two setups, we have a total difference of 50mm in the up component.

Example: Vector BDNC to NEW1, flagged as an outlier (???)

```
From  To    Type    Value      +/-      Calc       +/-      Res      +/-      S.R.
                    X,Y,Z               X,Y,Z               E,N,U

BDNC  NEW1  GB       707.702   0.007      707.676   0.004   -0.006   0.003    1.66
                   -1470.483   0.004    -1470.486   0.002   -0.005   0.003    1.36
                    -978.368   0.006     -978.384   0.003   -0.030   0.007    4.33   ???
                    1902.726             1902.727            0.031            2.79   ???

BDNC  NEW1  GB       707.659   0.007      707.676   0.004    0.002   0.003    0.59
                   -1470.487   0.004    -1470.486   0.002    0.002   0.003    0.64
                    -978.396   0.006     -978.384   0.003    0.020   0.007    2.92   ?
                    1902.728             1902.727            0.021            1.76   ?
```

The outlier should be rejected from the adjustment (Section 4.2.2).

> **NOTE:**
>
> An error in at a basestation can effect all the observations to and from that station. However, SNAP may not triple flag all or any of the observations. For example:
>
> > If the height at a basestation was incorrectly measured, all of the height observations at all the marks connected to during that setup will also be incorrect. Unless marks are measured from a second base station, it is unlikely that any outliers will be identified, despite the presence of a significant error.

7.2.2. Redundancy Test

The redundancy test is only checked in a minimally constrained adjustment and should be checked only after any observations are rejected from the adjustment and correct weighting has been applied. Redundancy implies that there are multiple observations for a single measurement and more reliable results are produced when there are redundant measurements in a network.

Redundancy is expressed as a number between 0 and 1, where:

- 0 means no redundancy – the observation is unchecked, and

- 1 is perfectly redundant (adds no value to calculating co-ordinates in the adjustment).

The redundancy value of 99% of observations should be greater than 0.4, while all observations must have a redundancy greater than 0.1. Observations of low redundancy are only weakly checked by the other observations – they indicate a deficiency in the network design.

The most convenient method of checking the redundancy of each observation is using the Observations tab in SNAPPLOT (Section 6.1.4.3).

- Add the "Redundancy factor" column **Observations | Listing options**

- Click on the "Redundancy" header to sort by redundancy

Details	Stations	Observations				
From	**To**	**Type**	**Status**	**Std.res**	**Redundancy**	**Length**
BDNC	AVLN	GB		0.95	0.817	6180.94
AVLN	DEN2	GB		0.66	0.837	6604.87
AVLN	DEN2	GB		0.76	0.837	6604.87
AVLN	NEW1	GB		1.39	0.840	6931.17
AVLN	NEW1	GB		1.18	0.840	6931.17

The redundancy value can be improved with more independent observations and more ties between adjacent marks in the adjustment.

7.2.3. Relative Accuracy Test

The relative accuracy test (sometimes referred to as the local accuracy test) is only checked in a minimally constrained adjustment and should be checked after any observations are rejected from the adjustment and correct weightings have been applied.

The relative accuracy test checks the accuracy between all possible pairs of marks in the adjustment (regardless if there is an observed vector between them or not).

The relative accuracy test must be tested for both the horizontal accuracy and vertical accuracy using the calculated a priori errors at the 95% confidence interval.

For Order 5 surveys, the relative accuracy test must not exceed:

(i) $\sqrt{0.01^2 + (dist \times 0.00005)^2}$ m horizontally, where *dist* is the distance between the two marks, and

(ii) $\sqrt{0.02^2 + (dist \times 0.00010)^2}$ m vertically, where *dist* is the distance between the two marks,

These tests can be run using the gpstest.cfg configuration file. The following should be entered in the SNAP command file, to test Order 5 local accuracy:

test_specification order_5 all

The results of this test are then available in the listing file (Section 5.4), in the Accuracy Specification Tests section under the heading *Relative accuracy tests*.

At the top of the Accuracy Specification Test section, SNAP states the accuracy tolerances being tested.

> **NOTE:**
>
> If you have changed the values in the gpstest.cfg Configuration File, it is a good idea to check that the correct values are being used for this test.

There is then a brief report stating:

- The number of stations tested

- The number of vectors tested

- The number of vectors that failed

- The largest error (and the vector this occurred at)

Example: Listing File – Relative accuracy tests

```
Relative accuracy tests

Horizontal tolerance:
    Stations tested:                    5
    Vectors tested:                    10
    Vectors exceeding tolerance:        0
    Largest error/tolerance:         0.23  (DEN2 to NEW1)

Vertical tolerance:
    Stations tested:                    5
    Vectors tested:                    10
    Vectors exceeding tolerance:        0
    Largest error/tolerance:         0.19  (DEN2 to NEW1)
```

If the relative accuracy test fails, consider observing additional vectors between the failing stations.

7.3. Constrained Adjustment

Once the minimally constrained adjustment tests have been completed and the adjustment passes you can then constrain the adjustment – hold the control stations fixed.

Example: Command file with control stations fixed

```
title SNAP Order 5

coordinate_file SNAPm.csv csv format=mdfc1

data_file SNAPv.csv csv format=vecc1rej

configuration gpstest
test_specification order_5 all

!Minimally Contrainsed Fixed Station:
!fix AVLN

!Constrained Fixed Stations:
fix AVLN WGTN BDNC
```

As additional marks are being held fixed, if there are any errors in the fixed co-ordinates, these will become apparent, through an increase in the SEUW and residuals. However we are no longer interested in maintaining a SEUW close to 1 – that is a test that is completed on the minimally constrained adjustment (Section 7.2).

7.3.1. Absolute Accuracy Test

Once the minimally constrained adjustment tests have passed (Section 7.2) and the control stations fixed/constrained, the absolute accuracy test (sometimes referred to as the network accuracy test) can be completed.

The absolute accuracy test checks the accuracy for every mark in the adjustment, in terms with the fixed control.

The absolute accuracy test must be tested for both horizontal accuracy and vertical accuracy using the calculated a priori errors at the 95% confidence interval.

For Order 5 surveys, the absolute accuracy test must not exceed:

        (i)   0.07 horizontally,

        (ii)   0.15m vertically.

These tests can be run using the gpstest.cfg Configuration File (Section 4.4.1). The following should be entered in the in SNAP command file, to test Order 5 network accuracy:

    test_specification order_5 all

The results of this test are then available in the Listing File (Section 5.4), in the Accuracy Specification Tests section under the heading *Absolute accuracy tests*.

At the top of the Accuracy Specification Test section, SNAP states the accuracy tolerances being tested.

There is then a brief report stating:

- The number of stations tested

- The number of stations that failed

- The largest error (and the station this occurred at)

Example: Listing File – Absolute accuracy tests

```
                    ACCURACY SPECIFICATION TESTS

===============================================================================

Testing order specifications: ORDER_5

Based on 95.00 apriori confidence limits
Horizontal accuracy: (error multiplier:   2.45)
           Absolute:  70.0 mm
           Relative:  10.0 mm   50.000 ppm
Vertical accuracy:   (error multiplier:   1.96)
           Absolute: 150.0 mm
           Relative:  20.0 mm  100.000 ppm


-----------------------
Absolute accuracy tests

Horizontal tolerance:
    Stations tested:                5
    Stations exceeding tolerance:   0
     Largest error/tolerance:       0.10 (WGTN)

Vertical tolerance:
    Stations tested:                5
    Stations exceeding tolerance:   0
     Largest error/tolerance:       0.07 (WGTN)
```

If the absolute accuracy test fails, consider observing additional vectors to the station(s) identified, or connecting to an additional control mark near the station(s) that fail.