GOVERNMENT OF SAMOA

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COMPONENT 5.01: LAND ADMINISTRATION AND SURVEY

GPS ADJUSTMENT MANUAL

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1. INTRODUCTION

The GPS Adjustment Manual has been prepared as a guide to assist in the adjustment of GPS data using the Microsearch GeoLab adjustment software. It was developed by Andrew Dyson, Team Leader/Geodetic Adviser. Development was undertaken under the Government of Samoa (GoS) Second Infrastructure Asset Management Program (SIAM-2), Component 5.01 - Sustainable Management, Land Administration and Survey Technical Assistance Program.

These instructions should be reviewed regularly and updated as required.

Refer to the *Microsearch GeoLab 2001 Field Manual* and the *GPS Environment for GeoLab User's Manual* for more detailed instructions on the many features in these two programs. An electronic copy of these manuals is available and should be installed on any computer used for adjustments. All or part of these manuals may be printed

In addition the Microsearch GeoLab and the GPS Environment on-line Help Systems are a comprehensive reference that provides detailed information about both software packages.

2. NETWORK ADJUSTMENTS

2.1 Overview

To determine the final coordinates of points observed with GPS, all baselines in the particular project (network) must be adjusted using a least squares adjustment program. Not only will the adjustment provide the final coordinates but it enables an evaluation of the quality of both the observations and the final coordinates.

It is therefore essential to adjust the data to determine if the results meets the specifications for the project and hence its acceptability.

In any observations (or measurements) there are small errors or inconsistencies as it is impossible to make a perfect measurement of any physical quantity. All measurements are estimates of the true value of a quantity, whether it is a distance, an angle, height difference or GPS baseline. In a network adjustment the inconsistencies in the observations are statistically removed by assigning residuals to the observed quantities. In a least squares adjustment, the residuals are assigned such that the sum of the squares of the residuals is a minimum. The observations are adjusted (by assigning the residuals) so that they are consistent with the geometry of the network

The Trimble Geomatics Office software provides a least squares adjustment facility but Microsearch GeoLab is the preferred program.

2.2 Microsearch GeoLab Overview

GeoLab can do much more than network adjustments. It can also perform many related functions including coordinate transformations, map projection computations and geoid computations.

It is capable of adjusting not only GPS data but any form of survey data including but not limited to conventional angles and distances, and levelling. Adjustments may be vertical, horizontal, three dimensional or mixed dimensional networks. There is no limit to the number of stations or observations that can be adjusted.

For a full listing of the capabilities, refer to the GeoLab Features Summary on page 4 of the *Microsearch GeoLab 2001 Field Manual*. The manual is available in PDF format and should be installed on any computers to be used for GeoLab adjustments. In addition there is a comprehensive On-line Help System that the user is encouraged to explore and use when necessary.

2.2.1 Software Protection

The software is protected by a licensing system, rather than a software key (or dongle). The software may be loaded on a number of computers but may only be run after transferring a licence to the particular computer. The licence may be transferred by the internet or via floppy disk. The process involves the transfer of a file between the two computers. See *10.1 – Licence Transfers* below for details.

2.2.2 Software Updates & Support

The GeoLab software must be kept up to date to ensure that it continues to provide the full level of support. GeoLab updates are made from the Microsearch website and therefore internet access is vital. The Microsearch website (http://www.msearchcorp.com) should be checked regularly for updates.

Two copies of the GeoLab software were purchased by MNREM in August 2005 (Purchase ID **82378573**)

The software was purchased together with the Microsearch "Subscription Package" which provides a guarantee that the next major upgrade to the software will be provided free of charge. Full details on the subscription package can be found on the Microsearch website.

The subscription package should be maintained to ensure access to the latest software upgrades and support.

2.3 GPS Environment for GeoLab Overview

The GPS Environment for GeoLab is a powerful utility program that makes the operation of GeoLab much simpler for most GPS adjustments. The GPS Environment was sold as a component of earlier versions of GeoLab (ver3.* and earlier). It is not sold with Microsearch GeoLab and is not supported by Microsearch.

Accordingly there are some instances of incompatibility and either program may at times experience small problems when they are used together. However the GPS Environment is so useful that these small problems can be tolerated.

Dr Robin Steeves has indicated that Microsearch is developing a new user interface for GeoLab with the same functionality as the GPS Environment. To be called *Network Assistant* it will be incorporated into the next version of GeoLab that is under development.

The GPS Environment provides a "user friendly" interface for adjusting GPS data. From the GPS baselines created by the GPS receiver manufacturer's software package, the Environment will set up the necessary files for a GeoLab adjustment.

Within the GPS Environment, GPS data types (for different receivers and baseline processing packages) can be specified, coordinates can be fixed and observations can be edited or removed. Without leaving the Environment, the adjustment is undertaken by GeoLab.

The Environment has many more capabilities and full details can be found in the *GPS Environment for GeoLab User Manual*. The manual is available in PDF format and should be installed on any computers to be used for GeoLab adjustments. In addition there is a comprehensive On-line Help System that the user is encouraged to explore and use when necessary.

3. EXPORT OF DATA FOR ADJUSTMENT

3.1 Export of Data from TGO

Baseline processing results must be exported from the relevant Trimble Geomatics Office (TGO) project in ASCII format before they can be incorporated into a GeoLab adjustment. It is suggested that baseline data is exported on a session by session basis to simplify keeping track of which data is in an adjustment.

To export the baseline results:

- In TGO open the project with the processed baselines to be exported.
- Select the required baselines and the relevant points. (baselines & points will be highlighted)
- From the Menu, select: File/Export.
- Export dialog box opens.
- From the Survey tab, select: Trimble Data Exchange Format (*.asc).
- Ensure that the "Selection" button is selected from the "Export" box.
- Click: OK
- Save As dialog box opens.
- Type: File name (maximum 11 characters)
- Ensure that "Save as type" is "Trimble Data Exchange Format (*.asc)."
- It is suggested that you save to the default "Export" directory in the particular project.
- Click: Save

The ASCII baseline processing results file will be saved to the selected directory.

3.2 Preparation of Exported File for Adjustment

The TGO ASCII file must be edited before importing into a GeoLab adjustment. It should be copied to the appropriate adjustment directory and then edited.

Create an appropriate directory or directories under C:\GeoLab 2001 Projects\ for processing of network data (eg. \Apia Second Order). Create a further directory under the processing directory for storage of the TGO ASCII files (eg. \baselines) and copy the ASCII files to this directory. **Data must not be stored or processed in the Program directories.**

Use a text editor such as "Wordpad" or "GeoLab" to edit the TGO ASCII files. Open the appropriate files and remove the two headings "Keyed in Coordinates" and "Observed Coordinates" and the relevant lines of data associated with each heading. Save the file and exit from the editing program.

4. INITIAL ADJUSTMENT RUN

4.1 First Steps

Wherever possible, the GPS Environment for GeoLab will be used to control the adjustment processes. Most options will be defined by the GPS Environment, however some must be set within GeoLab and it is recommended that these are set before starting with the GPS Environment.

4.1.1 Adjustment Options

It is suggested that three important options should be set within GeoLab. These options are as follows:

Scale Residual Variances:- GeoLab will multiply the residual variances by the estimated variance factor. The effect will be that few residuals should be flagged and the histogram will be well distributed. The variance factor reflects the overall fit of the input error estimates with the observations.

Experience indicates that the input error estimates from most if not all GPS processing packages are overly optimistic and that unless the residual variances are scaled by the estimated variance factor most residuals will be flagged. This makes it difficult to analyse the adjustment and detect the true outliers (or poor quality baselines). Although GeoLab may not always flag an outlier observation after setting this option, any observations that are flagged should be examined closely.

In some cases it will be obvious that the observations with flagged residuals are OK (low residual, low residual PPM and usually a short line). However, if a residual is large, has a high residual PPM, or the baseline error estimate (input sigma) is large, then there is most likely a problem with the observation.

This option should be used to look at the free net adjustment to identify outliers before scaling the input error estimates within the GPS Environment.

Print 3D Residuals as N, E, Up:- For the adjustment of GPS measurements it is recommended that this option is selected because residuals displayed in dX, dY & dZ are not very informative, and are difficult to interpret and analyse.

By setting this option, GeoLab will display all residuals for 3D observations with respect to a horizontal projection and in a vertical direction. This will be stated at the top of each page of the residual output. Seeing the residuals in this way is more informative because it can enable the detection of errors in antenna heights which will be reflected in the "Up" direction. Remember that antenna heights are a major source of error in GPS observations as they may be either measured incorrectly or entered into the receiver or on the field sheet incorrectly.

In addition it isolates the error in the height component which can be expected to be 2-3 times the error in the horizontal components.

Generate Initial Coordinates:- GeoLab will, if required generate initial coordinates for the adjustment, however you must provide a minimum of one control point. Alternatively each point in the adjustment must be provided with an initial coordinate. The accuracy of these coordinates is not critical, however it is important that the geometry of the network is properly represented. It is suggested that the best possible coordinates should be used. Provided that baselines have been processed using the best possible coordinates, it should follow that the best possible values will be reflected in the initial coordinates.

The initial coordinates are created when the network is built from the baseline results. The content of the baseline results file(s) dictates whether or not initial coordinates will be provided for all points. Using the procedures outlined in *3.1 - Export of Data from TGO* above, initial coordinates should be provided for all points. However as a precaution against not providing initial coordinates for some points it is suggested that the option to generate initial coordinates is always set.

To set these options:

- Start GeoLab by double clicking the Microsearch GeoLab icon on the desktop.
- From the Menu, select: Tools

- Select: Edit Default Options
- Edit Project Options sheet opens with five different tabs available.
- To set the options suggested above:
- Select the Statistics tab and ensure that the following is checked in addition to items that are already checked:
- Variance Factor: Scale Residual Variances
- Select the Output Configuration tab and ensure that the following is checked, in addition to items that are already checked:
- Output Options: Print 3D Residuals as N, E, Up
- Select the Adjustment tab and ensure that the following is checked, in addition to items that are already checked:
- Computation Options: Generate Initial Coordinates
- Click OK

If no further options are to be set, exit from Microsearch GeoLab.

4.1.2 Other Adjustment Options

If you wish to display map grid coordinates as part of the adjustment output (list file), an appropriate Map Projection Definition must be included in the options file. Note that the map projection must be on the same datum as the adjustment and GPS baselines.

If a map projection is defined in this manner, it is possible to extract grid coordinates using the Coordinate Listing function rather than the Transform Coordinates function. The Coordinate Listing function provides greater control over the output as the number of decimal places can be specified.

The Map Projection Definition may be included in the options file using "Edit/Insert/Projection" from within Microsearch GeoLab. The alternative and recommended method for defining a map projection for the adjustment is from the GPS Environment, see *4.4.3 – Adjust Network*, below for instructions.

Having defined the map projection it is also necessary to specify that grid coordinates are required in the output. To display the grid coordinates in the adjustment output.

- From the Menu, select: Tools
- Select: Edit Default Options
- Edit Project Options sheet opens with five different tabs available.
- Select the Output Composition tab and ensure that the following are checked:
- Print Adjusted Values: PLH Values and NEH Values.
- Click OK

Exit from Microsearch GeoLab.

4.2 Starting the GPS Environment

To start the GPS Environment, double click the GPS Env icon on the desktop, or access the program through the Start bar. Note that the screen will display GPS Env for GeoLab 3, an older version of GeoLab.

The sub-sections below cover each of the menu items for the GPS Environment. Within each sub-section the various options that are needed to run an adjustment are explained.

4.3 Network Setup

To open the necessary network files and select the GPS data type.

4.3.1 Open Network

To open the necessary network files.

- From the Menu, select: Network Setup
- Select: Open Network
- Select the directory for the network and enter the file name to be used for the adjustment files. It is suggested that a numbering convention is used so that subsequent adjustments of the same data or succeeding runs with additional data can be distinguished from each other. (eg Apia Second_01 for the first run, and Apia Second_02 for the second run etc.) See *8. – FILE MANAGEMENT* below for more information about files.
- Click: Open
- The network name will be displayed in the banner.
- The network path will also be displayed.

4.3.2 GPS Data Type

To select the GPS data type.

- If a GPS data type has been selected it will be displayed. If not displayed or the data type is to be changed:
- From the Menu, select: Network Setup
- Select: GPS Data Type
- Select: Trimble Geomatics Office
- Click: OK
- Extension: *.ASC
- Click: OK
- The GPS data type will be displayed as Trimble Geomatics Office.

4.4 Network Data

This is the main menu item for adding baseline data, setting adjustment options and running the adjustment.

4.4.1 Build Network

To add GPS baseline data to the open network (building the network):

- From the Menu, select: Network Data
- Select: Build Network

- Data Solution Files sheet opens.
- Select the directory where the GPS baseline solution file or files are located.
- The available solution files will be displayed.
- Select the appropriate file or files. The files will be added in the order they appear on the screen. If you want the files added in a different order, it is suggested that you add the solution files one at a time.
- If desired a group name can be assigned at this stage. (Group names are usually only assigned if data from different receivers, processing software or with very different observation periods are to be included in the same adjustment.)
- Click: OK
- Baselines will be built into the network files. Add further baselines from other files, if required, as above.
- Click: Finished
- Three files are created, using the example above they would be: Apia Second_01.APX (coordinate listing); Apia Second_01.GPS (GPS baselines with variance covariance matrices {VCVs}); and Apia Second_01.SUM (summary listing of baselines). These are text files and may be viewed with any text editor or viewer. However be careful not to change any data or formatting as this will affect the adjustment. **Only very experienced users who understand the full implications of any changes should edit any of these files.**

4.4.2 Control Coordinates

For a minimally constrained or free net adjustment there must be one fixed point. Although the actual coordinate values of the fixed point do not matter in the free net adjustment, it is best to set the correct coordinates for the control point at this stage to avoid later mistakes.

To input the coordinates of the point to be held fixed:

- From the Menu, select: Network Data
- Select: Control Coordinates
- Control Coordinates sheet opens with a listing of the stations in the adjustment, the coordinate type (should be PLH for Latitude, Longitude & Ellipsoidal Height) and their control status (indicated by 0/1 flag for each component, 1 in the appropriate column indicates the component is fixed).
- Highlight the point to be held fixed.
- Click: Fix 3D
- Fix/Edit Coordinates sheet opens indicating the coordinates of the point to be fixed in the APX file.
- Edit the coordinates, using the best available WGS84 values.
- Elevation: Ellipsoidal (checked)
- Coordinate Type: Geographic (checked)
- Click: OK

- Returns to Control Coordinates sheet. The control status flags should be “111”
- Check that this is the only point fixed. If necessary unfix any other fixed points.
- Check that all points are designated as PLH, not PLO. If PLO is encountered it may be necessary to “fix”, change to ellipsoidal height and “unfix”.
- Click: Finished

4.4.3 Adjust Network

The network is now ready for the free net adjustment. To adjust:

- From the Menu, select: Network Data
- Select: Adjust Network
- Adjust Active Network sheet opens.
- Title: type an appropriate title describing the adjustment (73 characters including spaces are allowed).
- Check: Locate Ambiguous Station Names.
- If you wish to display map grid coordinates as part of the adjustment output (list file)
- Check: Select/Remove Map Projection for Output.
- Uncheck other options
- Undulation Model: Ignore Model (checked)
- Click: OK
- The program tests all station names to determine if the coordinates of any stations are within the prescribed distance of each other, indicating possible numbering/naming problems. If no problems, an appropriate message is displayed. If problem stations are found there is an opportunity to correct possible wrong names or ignore them.
- Click: OK
- Displays the Ambiguous Station Names sheet with the minimum station separation. Can recompute using a different separation or finish. This is the screen that is displayed if any problem stations are found. When satisfied with the test:
- Click: Finished
- If Select/Remove Map Projection for Output was checked:
- Displays the Select Map Projection sheet. Highlight the appropriate projection in the Map Projections Available box.
- Click: Arrow button to place the projection in the Map Projections Selected box.
- Click: Continue

The network should now be adjusted and Microsearch GeoLab will be opened. Note that there is a bug caused by the small incompatibilities between Microsearch GeoLab and the GPS Environment that may prevent the adjustment from running.

If so, the adjustment can be run from within GeoLab as follows:

- Start GeoLab by double clicking the Microsearch GeoLab icon on the desktop.
- From the Menu, select: Network
- Select: Process
- GeoLab Network Processing Setup dialog box opens.
- Select: Browse
- Select IOB File dialog box opens.
- Select the required IOB file from the appropriate directory. (eg C:\GeoLab 2001 Projects\Apia Second Order\Apia Second_01.IOB) and click “Open”..
- Under “IOB File Mode” ensure that “#Includes Only in IOB File” is checked.
- Select: Process Net

After adjustment, the list file (Apia Second_01.LST) is displayed and the Network Processing Completed sheet is opened. To display the network:

- Select: required drawing scales or “Scale to fit window” option
- Click: Draw Network

Displays a network map and the Adjustment Results Summary.

It is suggested that before analysing the results of the adjustment that the FGCC orders should be computed and appended to the list file and that the adjustment is backed up. The list file should be closed before proceeding to the Utilities menu.

4.5 Utilities

If necessary restore the GPS Env for GeoLab screen.

The utilities menu contains a number of useful items. These include: Compute FGCC Order; Pack IOB (Archive); and Copy Active Network. These three items are discussed below:

4.5.1 Compute FGCC Order

This feature calculates the US Federal Geodetic Control Committee orders for each directly connected pair of stations based on the relative confidence regions and the distance between the stations. This information is appended to the list file.

To compute the FGCC Orders:

- From the Menu, select: Utilities
- Select: Compute FGCC Order
- Displays FGCC Order Results and provides the option to append to the listing.
- Select: Yes
- Switch to Microsearch GeoLab.
- Open the revised list file.

4.5.2 Pack IOB (Archive)

This feature enables you to combine the Ascii files needed to re-run the adjustment into one file for archiving and easy retrieval if you need to run the adjustment again. Having packed these files you

can delete the other files related to that particular adjustment provided that you don't wish to run any transformations or extract any coordinates. See *9. - TRANSFORMATIONS & EXTRACTING COORDINATES* below for more information.

To archive the active network files:

- From the Menu, select: Utilities
- Select: Pack IOB (Archive)
- Pack Active Network (Full IOB in GeoLab 3 Format) sheet opens. It should open to the current directory of the active network and displays the suggested file name for the "packed" file. This is in the form of the active network name with the extension .OLD (Apia Second_01.OLD).
- Select: Save
- Displays a message indicating the names and paths of the "packed" and list files which are to be kept and a further message about any geoid file that might have been used with the adjustment.
- Click: OK

See the *GPS Environment for GeoLab User Manual* section 6.3.2 for further details.

4.5.3 Copy Active Network

This feature enables you to create a new set of active network files for the next adjustment run which is recommended. (see *8. - FILE MANAGEMENT* below for more information). It is suggested that you create the new adjustment files after completing the analysis of the adjustment results (see *5. - ANALYSIS OF RESULTS* below).

To copy the active network files:

- From the Menu, select: Utilities
- Select: Copy Active Network
- Copy "active network" Network Files To… sheet opens. It should open to the current directory of the active network and displays existing networks (.IOB files).
- Type the name of the new active network into the File name box. Usually you will increment the existing active network name by one, eg Apia Second_02.IOB
- Click: Save
- Displays a message indicating the new active network name and path.
- Click: OK

4.5.4 Unpack IOB (Un-Archive)

This feature enables you to recreate the ASCII files needed to re-run an adjustment from an archived (.OLD) file. See *4.5.2 - Pack IOB (Archive)* above, for instructions and information about creating the archived file.

The OLD file should be copied to the directory where you intend to store the adjustment files.

Ensure that your current "Active Network" is in the directory where you have your OLD file and where you intend the unpacked files to be stored. If you have an APX file in this directory select it using Network Setup/Open Network. If you don't have an APX file in this directory you can create

a dummy “Active Network” in this directory using Network Setup/Open Network and entering an appropriate name.

To unpack the archived file:

- From the Menu, select: Utilities
- Select: Un pack IOB (Un-Archive)
- Select: GeoLab3 Network
- Name of File to Unpack sheet opens. It should open to the current directory of the active network and displays all OLD files in the directory.
- Select: file to be unpacked (eg Apia Second_01.OLD).
- Select: Open
- Displays a message indicating the names and paths of the “New Active Network”
- Click: OK

Creates the APX, GPS, OPT & IOB files and returns to the GPS Environment Main Menu. See the *GPS Environment for GeoLab User Manual* section 6.3.3 for further details.

5. ANALYSIS OF RESULTS

5.1 Introduction

It is now a matter of analysing the results to determine the quality of individual baselines and the overall adjustment; the need for further iterations to improve the adjustment; and any possible reobservations. Before doing this you should backup the adjustment files as described in 4.5.2 above, if not already done.

Unless you have a very small network with very good data you can expect that it will be necessary to carry out a number of runs (iterations) to achieve a satisfactory adjustment. After each run, the results are analysed, the worst solutions will be commented out for the next run and the process repeated until a satisfactory solution is achieved. For the solutions that are commented from the adjustment, it may be a matter of reprocessing the baselines or reobserving the baselines to provide the necessary level of redundancy. Reprocessed or reobserved baselines will then be added to the adjustment to determine if they fit the network.

Note that when a baseline is reprocessed and added to an adjustment, the original baseline must be commented. Subsequently it may be decided that the original processing is preferred and may be restored, but you must ensure that only one of the two solutions is used in any adjustment run.

Analysis of an adjustment is subjective and there isn’t only one correct solution. As with analysis of baseline processing results there are no definite rules on what is or isn’t acceptable data nor on the exact way to approach analysis. What can be provided are some guidelines as to the parts of the adjustment that provide the key indicators in assessing the quality of the individual components of the adjustment and the overall network.

Successful analysis of an adjustment is a matter of experience and the necessary skills can only be acquired with practice and experience over a considerable time. In analysing the results it is necessary to examine a number of parts of the adjustment output to build an overall picture. With experience you will acquire the techniques for adjustment analysis, learn to recognise the indicators of poor data and determine when you have a satisfactory solution.

For large projects it is suggested that adjustments should be made regularly as the data is acquired and processed. By starting with a small portion of the network and gradually building the network as baselines are processed you can isolate problems as they arise. It is much easier to handle an adjustment in this manner rather than starting with all the data at the end of the project. It also enables you to organise any reobservations that may be necessary while the GPS teams are still working in the area. Unless you are very experienced you will find it very difficult to analyse a very large network that has been built in one operation.

5.2 The List File

The results of the adjustment are written to the list file (Apia Second_01.LST) and it is this file which must be inspected. The contents of the list file are determined by the options you set within both the Environment and GeoLab itself. The *GPS Environment for GeoLab User Manual* provides a very comprehensive explanation of the different elements of the both the input files and the output listing in *Chapter 8 – Understanding the GeoLab Listing* and it is recommended that users study this chapter and refer back to it regularly. It has a sample listing annotated in detail to explain both the input and output files.

If the list file is not displayed on your screen it may be opened in Microsearch GeoLab (preferred option) or within any text editor. Some of the key areas to examine are as follows:

5.2.1 Page Header

The page header gives the adjustment title, the GeoLab version, ellipsoid, units and page number. The ellipsoid should be checked.

Below the header on the first page is displayed the time and date the adjustment was started and the input and output files.

5.2.2 Parameters and Observations

The first page displays the number of parameters, observations and degrees of freedom (indicator of level of redundancy). Check this page to see if you have the expected amount of data in the adjustment. Check each run as you comment/restore observations and add extra baselines. If the numbers are not as expected perhaps you made a mistake in one of the above operations.

5.2.3 Summary of Selected Options

Check the displayed options and in particular on the first run of an adjustment, after changing options or if the output is not as expected.

5.2.4 Misclosures

The misclosures may be printed for each pass of the adjustment if required. The printing of individual misclosures is dependent upon the misclosure limit factor set in the options. The misclosures provide an indication of inaccurate initial coordinates in baseline processing and also may indicate point numbering problems.

5.2.5 Solution

Solution means each complete pass (or iteration) through the adjustment process. For each pass the correction applied to each coordinate element is listed together with the old and new value. The adjustment process will continue until the convergence criteria is met, that is none of the corrections exceed this value (usually set at 0.001m).

5.2.6 Adjusted Coordinates

The adjusted coordinates are displayed in the specified format which will usually be PLH (Latitude, Longitude & Ellipsoidal Heights). Other options may be chosen. After each coordinate the standard deviation of the adjusted coordinate is printed. Note that fixed stations will have sigmas of zero.

5.2.7 Residuals

One of the most important parts of the output is the display of the residuals for each baseline. Together with the residuals are displayed the observations (baseline components), the observation standard deviations, residual standard deviations, standardised residuals and residual parts per million (ppm). *Chapter 8 – Understanding the GeoLab Listing* of the *GPS Environment for GeoLab User Manual* provides an excellent description of the residual printout section and each of the entries. It is most instructive and provides a very useful guide to making sense of the residuals.

The following points should be noted concerning the observation standard deviations:

- If residuals are displayed as N, E, Up, (see *4.1.1 – Adjustment Options* above) the observation standard deviations will be transformed to these components, however the observations are still displayed as dX, dY, dZ components.
- If the “Scale Residual Variances” option is set “On” (see *4.1.1 – Adjustment Options* above) the observation standard deviations will be multiplied by the square root of the estimated variance factor.
- The observation standard deviations will be multiplied by the square root of the scalar (or multiplier) to be applied to the GPS data type as input through the Network Data/GPS Error Estimates/Modify GPS Error Estimates option in the GPS Environment.

It is essential that after each adjustment run, a thorough analysis is made of all the residuals and associated information. Pay particular attention to the observation standard deviations as these are a key indicator of the relative quality of the baselines. Do not just look at any flagged residuals and assume that they indicate a problem baseline. It may be that the problem baseline is not the one with flagged residuals.

As indicated above the analysis and cleaning (removal of bad data) is an iterative process. To achieve a satisfactory result the worst data (with similar levels of residuals and similar standard deviations) must be removed, the adjustment re-run and the process repeated until a satisfactory solution is attained. Any very bad data will affect the whole adjustment and must be removed first. Only by gradually removing the worst data in each subsequent run will you be able to effectively analyse and clean the whole adjustment.

In this process the aim is to achieve an adjustment with consistent quality data. In other words any baselines with much greater standard deviations should be removed even if they do not have larger than average residuals as they do not contribute effectively to a good solution. In running the minimally constrained (or free net) adjustment, this is what we are trying to achieve, in preparation for the constrained adjustment when all control points will be held fixed.

If an observation has residuals of zero and is flagged with ”*” to the right of the standardised residuals it indicates that one point is being “uniquely determined”, in other words there is only one baseline to a point and the baseline cannot be adjusted as there is no redundancy. This will often happen after commenting baselines from a solution. If this happens, either the commented baseline should be reprocessed to try to obtain a better solution or the baseline must be reobserved.

After reprocessing or reobservation the baseline is added to the adjustment to determine if an acceptable solution can be attained. Note that there is no way to be sure about the quality of a single (hanging) baseline in an adjustment. The observation standard deviations provide some indication and should be considered in planning reobservations but only by providing a redundant observation can the true quality be determined.

5.2.8 Histogram

The histogram plots the frequency of the standardised residuals to indicate their distribution. If the vertical bars fit well under the curve there are no outliers. Vertical bars to the left or right indicate outliers or flagged residuals. However, note that some of these may be trivial. The histogram should be used as a quick visual indication of the overall adjustment but does not replace a detailed scan of the residuals.

5.2.9 Statistics Summary

Ideally the variance factor should be near 1.0 for a minimally constrained adjustment. The variance factor will be affected by bad observations which will increase the value. The poorer the observations, the higher the variance factor will be. As bad observations are removed from the adjustment, the variance factor will decrease.

Most GPS baseline processing software packages are overly optimistic when providing the error estimates for baselines (although some are pessimistic) and understate the size of the standard deviations. Accordingly in an adjustment the input error modelling will not match the actual adjustment and the variance factor will be greater than 1.0 even after the removal of the bad baselines.

Modifying the GPS error estimates (scaling) will reduce the variance factor to near 1.0 however you must be careful not to do this before bad observations are removed from the adjustment. Only with experience obtained from adjusting a number of projects of a reasonable size, with a particular sort of GPS equipment and baseline processor, and with substantially the same observation methods will you come to know what variance factor to expect.

When more control is added to the network (constrained adjustment) the variance factor will usually increase unless the control fits the GPS observations very well. The variance factor will reflect the fit of the observations and the control.

5.2.10 Confidence Regions

There are two confidence regions listings, the point and relative confidence regions. If FGCC Orders have been computed and added to the listing, as recommended in *4.5.1- Compute FGCC Order* above, there will be an extra listing of the relative confidence regions and at the end of each line will be displayed the FGCC Order for that pair of points. Generally we are interested in the relationship between control points so pay greater attention to the relative confidence regions, the parts per million (ppm) and the FGCC orders which provide the final test of how well the observations meet the specifications.

The default display is for directly connected points (with observed baselines) however there is an option to display other confidence regions if desired. (Tools/Edit Default Options in GeoLab).

Note that for short baselines it may not be possible to meet the ppm specifications particularly for higher order control. If the ppm appears large for shorter baselines, compare the size of the error ellipse with others in the listing to determine if it is consistent with the rest of the adjustment.

6. FURTHER ADJUSTMENT RUNS

After completing analysis of the adjustment, it will probably be necessary to remove any outlier observations and run the adjustment again. As suggested in *4.5.3 - Copy Active Network* above subsequent runs should be made with a new set of active network files. Follow the instructions in 4.5.3 above to create the new active network then comment or restore measurements as described below.

6.1 Comment/Restore Measurements

This feature allows you to comment or restore measurements. Rather than deleting measurements (observations) from the network files, the preferred technique is to comment observations. In this way the original data remains in the files and can be restored at any time if required.

In GeoLab, all valid input records commence in column two. If any character appears in column one the particular line is ignored by the adjustment. This feature provides the method for commenting measurements. For a commented measurement a "*" is placed in the first column. This feature can also be used to include comments and labels in GeoLab input files.

When commenting a GPS baseline, a "*" is placed in column one for each line (record) of the baseline. Using the Comment/Restore Measurement function automatically places or removes the "*" without the user having to open the GPS file.

To comment or restore measurements (baselines):

- From the Menu, select: Network Data
- Select: Comment/Restore Measurements
- Comment/Restore Observation sheet opens and displays the contents of the summary file (*.SUM).
- Select the baselines to comment/restore. Note that multiple selections may be made using the usual Windows selection techniques, but it is suggested that you only select baselines visible in one screen at a time. For large files the "go to" function should be used rather than scrolling.
- Click Comment button or Restore button
- After commenting a "*" will appear in column one. Check that you have commented/restored the correct baselines.
- After completing commenting/restoring:
- Click Finished
- Returns to the GPS Environment screen.

6.2 Next Adjustment Run

After commenting/restoring observations you will be ready to re-run the adjustment. Repeat the steps in *4.4.3 - Adjust Network* above. Provided that you haven't added any additional data it is not necessary to select the "Locate Ambiguous Station Names" option and it should be unchecked until further data is added to the adjustment.

After running the adjustment repeat the suggested options in *4.5 - Utilities* above to compute the FGCC orders and archive the adjustment before analysing the output as suggested in *5. – ANALYSIS OF RESULTS* above.

Once an adjustment is cleaned of bad data, the next batch of baselines should be added to the adjustment and the above processes repeated.

When satisfied that the minimally constrained network for the whole project, together with any reprocessed and reobserved baselines, has had any inconsistent and outlier observations commented, and that the adjustment meets the required specifications it is time to run the final minimally constrained adjustment.

6.3 Final Minimally Constrained Adjustment

In the final minimally constrained adjustment, the GPS error estimates will be modified and the residuals should be displayed as dX, dY & dZ. Changing the display of residuals should not change the final coordinates however there may be small changes to the statistics, because the residuals will not be transformed. If desired these changes may be made over two runs rather than one.

When GPS error estimates are modified, the “Scale Residual Variances” option is set to “Off”.

Care should be taken in modifying the GPS error estimates to ensure that a reasonable value is used. The estimated variance factor from the last adjustment run may be used provided that there are sufficient observations to derive a reliable value, that all the adjustment has been cleaned of outlier observations and that the value is consistent with values derived from similar data sets.

To change the above options, ensure that you are in Microsearch GeoLab:

- From the Menu, select: Tools
- Select: Edit Default Options
- Edit Project Options sheet opens with five different tabs available.
- To set the options suggested above:
- Select the Statistics tab and ensure that the following is not checked:
- Variance Factor: Scale Residual Variances
- Select the Output Configuration tab and ensure that the following is not checked:
- Output Options: Print 3D Residuals as N, E, Up
- Click OK

Exit from Microsearch GeoLab.

To modify the GPS error estimates, return to the GPS Environment

- From the Menu, select: Network Data
- Select: GPS Error Estimates
- Select: Modify GPS Error Estimates
- GPS Error Estimates sheet opens.
- Enter the appropriate value in the box – “Full matrix to be multiplied by”
- Click: Apply changes

The adjustment should be run and the listing checked to ensure that each of the above steps was applied correctly. Check through the residuals to ensure that there are no substantial outliers. The estimated variance should now be very close to 1.0. There should not be other than very minor changes to the overall adjustment results and statistics apart from the variance factor.

The FGCC orders should be computed after the final minimally constrained adjustment as the ppms and orders are an indication of how well the observations fit with each other not to the existing control. In other words they indicate the quality of the observations and internal consistency of the free net adjustment.

It is now time to fix all control and run the final GPS adjustment.

6.4 Constrained Adjustment

To constrain the adjustment to all control points:

- From the Menu, select: Network Data
- Select: Control Coordinates
- In turn, highlight each point to be held fixed and do the following:
- Click: Fix 3D
- Fix/Edit Coordinates sheet opens indicating the coordinates of the point to be fixed in the APX file.
- Edit the coordinates, using the appropriate WGS84 values.
- Elevation: Ellipsoidal (checked)
- Coordinate Type: Geographic (checked)
- Click: OK
- Returns to Control Coordinates sheet. The control status flags should be “111”
- Repeat for the other fixed points.
- Check that all fixed points indicate “111” and that no other points are fixed.
- Check that all points are PLH records, not PLO.
- If necessary unfix any other fixed points.
- Click: Finished

Run the adjustment to obtain the final adjusted coordinates for each point.

Inspect the list file to ensure that the correct points have been fixed and that their coordinates are correct. View the statistics to determine how well the observations fit to the control. If there are any particular distortions associated with any of the control points it may be appropriate to unfix that point and to investigate the source of the coordinates for the point, that the correct point was occupied and that the point hasn’t been disturbed.

The FGCC Orders are not run after the constrained adjustment as the ppms and orders are an indication of how well the observations fit with each other not to the existing control. In other words they indicate the quality of the observations and internal consistency of the free net adjustment.

7. INTEGRATION OF CONVENTIONAL OBSERVATIONS

In some circumstances it will be necessary to include conventional observations in the GeoLab adjustment files. This will happen in the following circumstances:

- The designated control point is unsuitable for GPS observations because of obstructions. This will usually only happen if it is an existing mark, otherwise

control points should be selected in GPS suitable locations. The control point will be coordinated by traversing from two GPS control points.

Ideally it should be a triangle situation where the two GPS points are intervisible, the control point is also visible from both GPS points and can be occupied with a Total Station. It is desirable that the triangle is as close to an equilateral triangle as possible. All angles and distances should be observed.

There may be circumstances where the two GPS points are not intervisible in which case a traverse is run between the GPS control points. Every effort should be made to use equal length traverse legs.

All angles, slope distances, zenith distances, instrument and target heights are required.

- Where two GPS control points are within a short distance (less than 200 metres) of each other and are intervisible, it is desirable to measure the distance between the two points and include in the adjustment. Slope distances and instrument and target heights are required.

Traverse data must be entered into a file in the appropriate format (GeoLab input format – IOB). The file must be named using the same file naming convention as for the other adjustment files (see *4.3.1 - Open Network* above). The file should have the extension .COB (Classical OBservations), eg. Apia Second_nn.COB.

The reduced observations must be entered directly from the Traverse Pages. An alternative would be to record the observations automatically and then create the .COB file using a computer program. This would eliminate major sources of error and save considerable time.

The formats for each of the different record types are to be found in the *Microsearch GeoLab 2001 Field Manual.* See also the sample files, examples of these are reproduced in *7.1.3 – Format of the COB File* below.

7.1 Creating the COB file

The COB file should be created within a Microsearch GeoLab text window (see Page 121 of the *Microsearch GeoLab 2001 Field Manual*). It can be created using one of the following two methods:

7.1.1 Manual Method

You can start with a sample file and then use the editing functions to create your own records in the appropriate format. Note that you must be careful to maintain the correct alignment for the relevant fields and not enter any control characters such as tabs.

7.1.2 Record Editor Method

You can use the intelligent “Record Editor” to create or edit GeoLab input text records. It provides input text boxes for each of the required fields for each record type and automatically puts the information into the correct format. Drop down list boxes allow the user to choose preset options.

To start the “Record Editor”, open a text file then select Edit/Edit GeoLab Text Record, or select the appropriate button from the toolbar.

7.1.3 Format of the COB File

Part of a sample COB file is reproduced below:

```
San Miguel Terrestrial Observations

 HIST NEW

*                                                centring error
*               sdev                             from        to
 SIGM DIR        5.0                             .005       .005

* Traverse Page 1
 DSET DIR
 DIR      LYT-528      LYT-527                      0  0  0
 DIR      LYT-528      LYT-537                    306 51 24

 DSET DIR
 DIR      LYT-537      LYT-528                      0  0  0
 DIR      LYT-537      LYT-527                    287 47 28

 DSET DIR
 DIR      LYT-527      LYT-537                      0  0  0
 DIR      LYT-527      LYT-528                    305 21 23

* Traverse Page 2
*DSET DIR
*DIR      LYT-530      LYT-529                      0  0  0
*DIR      LYT-530      LYT-536                    317 53 27

*DSET DIR
*DIR      LYT-536      LYT-530                      0  0  0
*DIR      LYT-536      LYT-529                    264 16 57

*DSET DIR
*DIR      LYT-529      LYT-536                      0  0  0
*DIR      LYT-529      LYT-530                    317 49 35

END OF DIRECTIONS
 HIST GEN Histogram of Directions

 HIST NEW

*                                               centring error
*              sdev         ppm                 from        to

 SIGM DIS      0.003        2.0                 0.005      0.005
 SIGM ZAN      60.0

* SLOPE DISTANCES & ZENITH DISTANCES

* Traverse Page 1
 HI       LYT-528           1.300
 HT       LYT-527           1.020
 HT       LYT-537           1.124
 ZANG ZAN LYT-528      LYT-527                      89 47 34
 ZANG ZAN LYT-528      LYT-537                      89 36 34
 DIST DIS LYT-528      LYT-527                            143.372
 DIST DIS LYT-528      LYT-537                            122.807

 HI       LYT-537           1.120
 HT       LYT-528           1.210
 HT       LYT-527           1.020
 ZANG ZAN LYT-537      LYT-528                      90 28 53
 ZANG ZAN LYT-537      LYT-527                      90 11 00
 DIST DIS LYT-537      LYT-528                            122.809
```

```
 DIST DIS LYT-537      LYT-527                          120.482

 HI       LYT-527           1.102
 HT       LYT-537           1.124
 HT       LYT-528           1.221
 ZANG ZAN LYT-527      LYT-537                  89 53 43
 ZANG ZAN LYT-527      LYT-528                  90 16 42
 DIST DIS LYT-527      LYT-537                        120.482
 DIST DIS LYT-527      LYT-528                        143.371

 HI       LYT-528           0.000
 HI       LYT-537           0.000
 HI       LYT-527           0.000
 HT       LYT-537           0.000
 HT       LYT-527           0.000
 HT       LYT-528           0.000

END OF DISTANCES & ZENITH DISTANCES

 HIST GEN Histogram of Distances & Zenith Distances
 HIST ALL Histogram of all observations

END OF FILE
```

A full explanation of all the record types above can be found in the *Microsearch GeoLab 2001 Field Manual.* Attention is drawn to the following:

Within the sample COB file as with any other GeoLab input file, the presence of any character in column one indicates that the line is a comment and will be ignored by the adjustment process. This feature is useful as it allows the user to provide an explanation of the different observations and records. Examples are “San Miguel Terrestrial Observations”, “* Traverse Page 1” and “END OF DIRECTIONS” in the sample above. Note also, that blank lines are also ignored and are therefore useful to separate different records.

The HIST records control the production of histograms. The NEW option starts building a new histogram and the GEN option generates a histogram based on the observations since the last NEW record. The title is printed under the histogram. The ALL option is used to generate a histogram of all observations to that point. In the above example, a histogram will be generated for the Directions, a combined histogram for the Distances & Zenith Distances, and a combined histogram for all observations in the adjustment.

To generate a histogram for the GPS observations alone, the appropriate HIST records should be placed at the start and end of the GPS file.

To facilitate the production of histograms for each observation type as indicated above it is necessary to place all similar observations, eg Directions, together in the input file. An inspection of the sample COB file above illustrates this point. All other Direction records would be positioned before the “END OF DIRECTIONS” comment and the “HIST GEN Histogram of Directions” record.

For the Distances and Zenith distances, the data from only one Traverse Page is included to limit the size of the output. Data for other Traverse Pages would follow and appear before the “END OF DISTANCES & ZENITH DISTANCES” comment.

The SIGM record will normally be used to assign standard deviation information to the conventional observations. Some SIGM records may also contain ppm and centring error information to be applied to the particular observations. SIGM records contain a sigma-record identifier (columns 7-9). The sigma-record identifier is used in the observation records to specify

the relevant sigma-record and hence the error information for that particular observation. In the example above three different sigma-records are specified: DIR; DIS & ZAN.

Use of a SIGM record means that standard deviations need not be specified as part of the individual observation records. It provides a simple way of updating the error modelling for a set of observations without editing every record.

The DIR (direction) record specifies a horizontal direction observation. Each set of direction observations must begin with a DSET record and all observations in the same set must have the same from station. The sigma-record is specified in the DSET record (in the above example it is DIR).

The distance observations (DIST records) must be slope distances. Heights of instrument and targets (HI & HT records) must be provided. They must be reset to zero after each observation set. The ZANG (zenith angle) records are included with the DIST records.

If distances are included as check distances alone for close stations with EDM check distances but no traversing to non-GPS points, then it is not necessary to include any ZANG records, however HI & HT records are still required. An example is shown below:

```
San Miguel Check Distance Observations

 HIST NEW
*                                              centring error
*              sdev         ppm                from        to

 SIGM DIS      0.003        2.0                0.005      0.005

* SLOPE DISTANCES
* Traverse Page 1
 HI       LYT-528           1.300
 HT       LYT-527           1.020
 DIST DIS LYT-528      LYT-527                          143.372

 HI       LYT-527           1.102
 HT       LYT-528           1.221
 DIST DIS LYT-527      LYT-528                          143.371

 HI       LYT-528           0.000
 HI       LYT-527           0.000
 HT       LYT-527           0.000
 HT       LYT-528           0.000

* Traverse Page 2
 HI       LYT-530           1.370
 HT       LYT-529           1.230
 DIST DIS LYT-530      LYT-529                           79.433

 HI       LYT-529           1.320
 HT       LYT-530           1.320
 DIST DIS LYT-529      LYT-530                           79.433

 HI       LYT-530           0.000
 HI       LYT-529           0.000
 HT       LYT-529           0.000
 HT       LYT-530           0.000

END OF SLOPE DISTANCES

 HIST GEN Histogram of Distances

END OF FILE
```

7.2 Combining the COB file with the Adjustment

Before running the adjustment with the COB file, it is necessary to edit the IOB file to include the COB file. The IOB file contains a list of "INCLUDE" statements specifying the files to be included in the particular adjustment. The existing IOB file can be edited in GeoLab. An example is shown below:

```
#include C:\GeoLab 2001 Projects\Apia Tertiary\Apia 3rd_01.opt
#include C:\GeoLab 2001 Projects\Apia Tertiary\Apia 3rd_01.apx
#include C:\GeoLab 2001 Projects\Apia Tertiary\Apia 3rd_01.gps
#include C:\GeoLab 2001 Projects\Apia Tertiary\Apia 3rd_01.cob
```

When a traverse is run between two GPS control points without a backsight, GeoLab will have difficulty calculating approximate coordinates for the traverse points. In such situations it will be necessary to calculate approximate coordinates for inclusion in the APX file. The transformation functions available in GeoLab may be used to transform between grid and geographic coordinates.

The WGS84 coordinates for the traverse points are then added to the APX file, ensure that they are set as "PLH" type and that the fix flags are set to "000".

Run the adjustment and remember to set the "Locate Ambiguous Station Names" option the first time you include the terrestrial observations.

Archive the results using the "Pack IOB" feature in *4.5.2 - Pack IOB (Archive)* above and then analyse the results.

7.3 Analysis of Results

Analyse the results in the usual way paying particular attention to the following:

Check the GPS baselines to points with conventional data to ensure that the residuals are not significantly different from the previous run without conventional data. Any excessively large residuals may indicate a problem with the input traverse data or an inconsistency with the GPS data. Investigate and take the appropriate action.

The direction residuals should be consistent with the length of the traverse lines. Investigate any substantial residuals taking this into account. (Remember that 1" of arc subtends 0.0005m over a distance of 100m).

Note that the zenith distances will take large residuals.

The distance residuals should be quite small indicating that the GPS control fits the measured distances. Investigate any substantial residuals.

8. FILE MANAGEMENT

There are a number of files associated with each network. Some of these files are created by the GPS Environment as the network is created or built. In addition there a number of files generated each time an adjustment is run.

For a detailed explanation of these files refer to *Chapter 7 Advanced Topics* of the *GPS Environment for GeoLab User Manual.*

Most of the GeoLab files are binary files and do not need to be backed up (archived) because GeoLab will create them again if necessary by repeating the adjustment. Some of these files are

used by GeoLab when computing transformations, extracting coordinates and displaying the network so they should not be deleted until these operations are complete for a given adjustment.

The binary files for a large network are also large and may take up much disk space particularly if many runs are made of each adjustment. It is generally suggested that each subsequent run of an adjustment be given a new name (using the convention suggested in *4.3.1 - Open Network* above, the last part of the network name is a number which is incremented on subsequent runs).

It is therefore essential that necessary files are archived and the remaining files are deleted. Files should be archived using the Pack IOB (Archive) option from the Tools Menu. See *4.5.2 - Pack IOB (Archive)* above for detailed steps and refer to the *GPS Environment for GeoLab User Manual* section 6.3.2.

These archived files may be unpacked using the Unpack IOB (Un-Archive) option from the Tools Menu. See *4.5.4 - Unpack IOB (Un-Archive)* above for detailed steps, and refer to the *GPS Environment for GeoLab User Manual* section 6.3.3 for further information.

To create the new active network from an existing active network select the Copy Active Network option from the Tools Menu. See *4.5.3 - Copy Active Network* above for detailed steps and refer to the *GPS Environment for GeoLab User Manual* section 6.3.4.

9. TRANSFORMATIONS & EXTRACTING COORDINATES

Within Microsearch GeoLab there are tools for extracting coordinates from adjustments; for transforming coordinates between different datums; and transforming from geographic to grid coordinates or vice-versa.

9.1 Listing Adjusted Coordinates

Refer to *Microsearch GeoLab 2001 Field Manual* Page 167 for detailed instructions regarding the various options.

To produce a listing of adjusted coordinates, within GeoLab:

- From the Menu, select: Network
- Select: List
- Select: Adjusted Coordinates
- Use the browse button to select the Adjusted Network name from which the coordinates will be extracted, specify the Output Type (usually PLH or may be NEH if the appropriate map projection has been defined in the adjustment) and the Linear and Angular Decimal options.
- Click: Write List

The listing of adjusted coordinates will be displayed. The listing can be printed and/or stored, select a suitable extension for the file name. It is suggested that a suitable description is added to the file. Remember that comments must include a character in the first column to ensure that they will be ignored in any GeoLab operations.

9.2 Transformations - General

Refer to *Microsearch GeoLab 2001 Field Manual* Pages 183 to 192 for detailed instructions and explanations regarding the various options.

It is recommended that in all transformations, some control coordinates whose values are already known in the output datum or projection, are included as a check. (Suitable points would be existing control points)

It is very important to be aware of the datum for the coordinates to be transformed. Note that the GPS adjustment will always be done on the WGS84 datum.

There are three options for the input data into the transformation process. You may transform: manual input data (Sampler); a text file; or a GeoLab adjusted network.

To transform coordinates, within GeoLab:

- From the Menu, select: Tools
- Select: Transform Coordinates

The GeoLab Coordinate Transformer sheet opens with five tabbed option pages. The options for the transformation are set on these pages. Generally the following four pages will be used:

9.2.1 Input

Select the Input Type; Manual (Sampler); Text File; or GeoLab Adjusted Network

Select the Input File, using the Browse button.

Check that the correct Ellipsoid is set.

Select a Projection if appropriate.

9.2.2 Output

Select a Projection if appropriate.

Check Write Header Information to get a summary of the transformation process and options at the top of the output file. **(Useful to check the process.)**

Check that the correct Ellipsoid is set.

9.2.3 7-Parameters

Enter the 7 transformation parameters. **(Take care to enter the correct signs.)**

The most recent 7-parameter values used will be loaded automatically. The Load button can be used to load any previously stored values.

If doing the reverse transformation, ensure that the signs are reversed.

9.2.4 Transformation

Select the type of transformation to be executed and the From and To Types for the coordinate input and output.

Having set all the appropriate options, complete the transformation by selecting the Transform button.

10. SOFTWARE LICENSING

As indicated in *2.2.1 - Software Protection* above, the software is protected by a licensing system and the software may be loaded on a number of computers at the same time but may only be run if

the licence is loaded in the particular computer. Without a licence, the software may only be run in "demonstration" mode.

The licence transfer system is explained below:

10.1 Licence Transfers

In the licence transfer operation, the "source" and "destination" computers are referred to. The "source" computer is where the licence is currently installed. The "destination" computer is the computer to which the licence is to be transferred.

Before transferring the licence, the software must be installed on the destination computer. This can be done from the Microsearch website or from a CD or other storage device. Note that the website should be checked at regular intervals to determine if an upgrade is available.

On the "destination" computer, run *Microsearch GeoLab:*

- From the Menu, select: Help
- Select: Licensing
- The Microsearch GeoLab sheet opens indicating the current licence status and the available options
- Click: Licensing
- The Microsearch GeoLab sheet content changes
- Click: License Transfers
- A screen opens with information about the process.
- Click: OK
- The Transfer Licenses sheet opens. It depicts the licence process. The button for the next step should be enabled.
- Click: Step 1: Create Transfer File.
- Displays the message "The transfer file (transfer.dat) was successfully created. You should now move the transfer file to the source computer".
- Click: OK
- Closes the Transfer Licence sheet.
- Exit from Microsearch GeoLab.
- Using Windows Explorer, copy the transfer.dat file from the program directory, which should be: c:\Program Files\Microsearch\GeoLab, to a floppy disk or other transfer medium. (Note: ensure that the correct transfer.dat file is copied by checking the time created.)

On the "source" computer*:*

- Using Windows Explorer, copy the Transfer.dat file from the floppy disk or other transfer medium to the program directory, which should be: c:\Program Files\Microsearch\GeoLab.
- Run *Microsearch GeoLab,* this will load the transfer file.
- From the Menu, select: Help

- Select: Licensing
- The Microsearch GeoLab sheet opens indicating the current licence status and the available options
- Click: Licensing
- The Microsearch GeoLab sheet content changes
- Click: License Transfers
- A screen opens with information about the process.
- Click: OK
- The Transfer Licenses sheet opens. It depicts the licence process. The button for the next step should be enabled.
- In the box under the Source Computer select the number of licences to be transferred.
- Click: Step 4: Transfer License(s) Out.
- The Transfer License(s) Out sheet opens. It advises that you are about to transfer the licence to the transfer file.
- Click: Yes.
- Displays the message "The requested number of licenses were transferred to the transfer file. You should now move the transfer file back to the destination computer."
- Click: OK
- Closes the Transfer Licence sheet.
- Exit from Microsearch GeoLab.
- Using Windows Explorer, copy the Transfer.dat file from the program directory, which should be: c:\Program Files\Microsearch\GeoLab, to a floppy disk or other transfer medium.

On the "destination" computer*:*

- Using Windows Explorer, copy the Transfer.dat file from the floppy disk or other transfer medium to the program directory, which should be: c:\Program Files\Microsearch\GeoLab.
- Run *Microsearch GeoLab,* this will load the transfer file.
- From the Menu, select: Help
- Select: Licensing
- The Microsearch GeoLab sheet opens indicating the current licence status and the available options
- Click: Licensing
- The Microsearch GeoLab sheet content changes
- Click: License Transfers
- A screen opens with information about the process.

- Click: OK
- Displays the message “A file containing “n” licence(s) has been found. Do you wish to load the licence(s) from that file?”
- Click: Yes
- Displays the message “The licence(s) were successfully loaded”
- Click: Ok
- Closes the Transfer Sheet.
- Check the licence status to ensure that the transfer has been successful.
- From the Menu, select: Help
- Select: Licensing
- The Microsearch GeoLab sheet opens indicating the current licence status and the available options