PHILIPPINES-AUSTRALIA LAND ADMINISTRATION AND MANAGEMENT PROJECT

GPS PROCESSING

&

ADJUSTMENT

MANUAL

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Table of Contents

1. INTRODUCTION

The GPS Processing & Adjustment Manual has been prepared as a guide to assist in the processing of data from the Leica SR520 GPS Receivers using the SKI-Pro software and the adjustment of processed data using the Microsearch GeoLab adjustment software. It was developed by Andrew Dyson, Survey Control Adviser, under the Philippine – Australia Land Administration & Management Project Technical Assistance Program.

These instructions should be reviewed regularly and updated as required.

Refer to the *Leica User Manual; Getting Started with SKI-Pro* for specific instructions on using SKI-Pro and for items not covered in this manual. An electronic copy of *Getting Started with SKI-Pro* and other Leica GPS documentation is available on the Leica GPS System 500 CD and should be installed on any computer used for GPS processing together with the other electronic documentation. All or part of *Getting Started with SKI-Pro* may be printed.

In addition the SKI-Pro On-line Help System is a comprehensive reference that provides detailed information about the whole software package.

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. SKI-PRO OVERVIEW

SKI-Pro (**S**tatic- **KI**nematic-**Pro**fessional) is a GPS post-processing and data management software package provided by Leica Geosystems for use with their GPS System 500 Hardware. The software provides the capability for GPS mission planning, download of observed data from the Leica GPS receivers, data processing, adjustments, transformations and export of data. As GeoLab will be used for the adjustment of processed GPS data, SKI-Pro will be used primarily for the downloading and processing of data. Accordingly this manual will not consider SKI-Pro adjustments.

2.1 Software Protection

The SKI-Pro software comes with a green SKI-Pro software protection key (often referred to as the dongle). The software may be installed on a number of computers but some components of the software are not accessible unless the dongle is attached to the parallel port of the computer.

The unprotected components of SKI-Pro that may be used without the green dongle are:

- Satellite Availability
- Data Import
- RINEX Export
- ASCII Import / Export
- Project Management
- Coordinate Set Management
- Coordinate System Management

- Sensor Transfer
- View and Edit
- Codelist Management
- Antenna Management

The protected components that require the dongle to be attached to the parallel port of the computer are:

- Data Processing
- Datum and Map
- Adjustment
- RINEX Import
- GIS / CAD Export (Note: this option is not available on the current LAMP licence)

2.2 Software Navigation Tools

See pages 21 & 22 of *Getting Started with SKI-Pro* for an explanation of the navigation tools. There are usually a number of ways to navigate through the software, you may choose the tools you prefer. To select commands you may use the Menu Bar, Toolbar or the Context-Menu available by a right click of the mouse button.

The right click and the Context-Menu are very powerful and useful ways of navigating through the software.

2.3 Views

See pages 23 to 25 of *Getting Started with SKI-Pro* for an explanation of the various views available to display and list information about the current project.

2.4 On-line Help

The On-line Help System is a comprehensive reference for SKI-Pro. Information not found in *Getting Started with SKI-Pro* can be found using the Help System. See pages 26 & 27 of *Getting Started with SKI-Pro* for an overview of the system.

2.5 Software Updates

The SKI-Pro software must be kept up to date to ensure that it continues to provide the full level of support. It includes free upgrades for one year from the date of purchase. After this period has elapsed it will be necessary to enter into a software upgrade agreement.

Appropriate arrangements should be made with the Leica dealer to ensure that any upgrades are forwarded promptly to PIO1.

The cost of future software upgrade agreements should be determined from the dealer and included in the annual budget.

3. GETTING STARTED WITH SKI-PRO

3.1 First Steps

Ensure that the green SKI dongle is attached to the parallel port of the computer.

To start SKI-Pro, double click the SKI-Pro icon on the desktop, or access the program through the Start bar.

As indicated in *2.2 – Software Navigation Tools* above there are a number of alternative ways of navigating through the software and menus. The instructions that follow will usually provide one method which is not necessarily the best method or the method that you will prefer to use. Be prepared to try different methods to familiarise yourself with the software's capabilities and then adopt the methods that suit you.

3.2 Project Management

Data is organised within SKI-Pro in Projects. A single project should contain related data, eg all Second Order control for a project; the Third Order Control for a Municipality; photo control point data for a specific area, or data for an individual day or session.

For large projects where processed baselines will be regularly exported for adjustment in GeoLab it may be more convenient to create a new project for each day or session. In this way it is a simple matter to export each batch of data independently. It is up to the project leader to determine the most appropriate method of data management for the particular project.

In Project Management you can create, open and edit projects.

Projects or any files contained within a project must never be deleted from outside SKI-Pro. Always use Project Management to delete unwanted projects or data within a project.

3.2.1 Creating a New Project

To create a new Project:

- From the Menu, select: File.
- Then select: New project.
- On the General Tab.
- Enter: Project Name.
- If necessary, define: Location (usually in C:\SkiPro Projects\ )
- If necessary, change: Limits for Automatic Coordinate Averaging & Time Zone.
- On the Coordinates Tab
- Ensure Coord System is: WGS 1984.
- Select: OK. (new project is created)

3.3 Importing Observed GPS Data into a Project

GPS observations are recorded on a PCMCIA card (PC-card) in the GPS receiver. This data is transferred (downloaded) to the computer for baseline processing. When using a notebook computer the PC-cards are inserted, in turn, into one of the available PC-card slots. If using a desk top

computer, either a PC-card reader is required or the data can be downloaded by using a download cable from the GPS receiver to the computer.

The PC-card should only be removed from the GPS receiver when it is switched off or when the PC-card Status Icon at the top of the display has an arrow pointing down the screen. The arrow indicates that it is safe to remove the PC-card. Removing the PC-card at other times may corrupt the data on the card and make it unreadable.

Take care as the PC-card may be very hot immediately after use.

When data is downloaded to the project there is the opportunity to view and modify user input data, in particular Pt ID's and antenna heights. The opportunity should be taken to check this information at this time and if necessary edit it.

In addition the import process enables the raw data to be backed up. The raw data should be backed up to the hard disk and at a later stage it can be transferred to a more permanent storage device, such as a network drive or a CD. A suitable directory should be established on the computer for backups (eg. C:\GPS Raw Data Backup). It is suggested that within that directory, a sub-directory should be created for each observation session (eg, D13502-1)

To import data:

- Insert the first PC-card into the PC-card slot, with the Leica logo up and in the direction of the arrow, (assuming use of a notebook computer), push home fully. The computer should immediately recognise its presence and will normally give an audible indication.
- Open the appropriate Project.
- From the Toolbar, select: Import GPS Raw Data; or,
- From the Menu, select: Import, then GPS Raw Data.
- The Import GPS Raw Data dialog opens.
- If necessary change drive and directory to the one containing the raw data (usually E:\Geodb\.
- The dialog box will list the jobs on the PC-card. The listing indicates the job name entered in the receiver before the observation and the Sensor ID (receiver serial number) eg D13502-1-0580, where the first 8 characters are the job name and the last four characters the Sensor ID.
- Highlight the job/jobs click: Import
- The Assign Property Sheet appears.
- Highlight the Project Name
- Select the View Data tab
- Check and if necessary edit the Pt ID (compare with the GPS field sheet and schedule – ensure that the correct naming convention is used) and Antenna Height (compare with GPS Field Sheet). Any editing should be done before the backup and assign process to ensure that the correct data is backed up and assigned.
- Check the antenna type and measurement method against the GPS field sheet. If incorrect, they must be edited after the import process and before processing. (see *4.2 –Editing Data* below)

- If there are any very short intervals of data or other data that is not to be processed they may be deleted at this stage.
- Return to the General tab
- To backup raw data, select: Backup
- Choose Location dialog opens.
- If necessary change drive and directory to the desired backup directory or create a new directory. (eg. C:\GPS Raw Data Backup\D13502-1)
- Select: OK (copies the edited raw data files to the directory)
- Returns to Assign Property Sheet.
- Ensure that the project is still highlighted.
- Select: Assign (assigns data to the current Project)
- Select: Close
- Returns to the Project Graphical View.
- The PC-Card should be removed and the above procedure repeated for the remaining PC-cards. **Before removing the PC-card you must ensure that the card is ready for removal.** The procedure may vary depending upon the computer and the operating system. As a general rule, right click on the PC-card icon at the bottom of the screen and follow through the procedures until given a message that it is safe to remove the card. **(Take care as the PC-card may be very hot)**
- Repeat the above procedure for each PC-card to be downloaded.

3.4 Deleting GPS Data from the PC-card

GPS data may be deleted from the PC-card from within the GPS receiver or within SKI-Pro using the Import Menu. Data should only be deleted by Jobs and should not be deleted using Windows Explorer as this will corrupt the data base on the PC-card.

It is recommended that data should be deleted by the project leader on a regular basis rather than in the field by the GPS teams. The PC-cards hold 16mb of data which is sufficient for many days' observations. It is suggested that the oldest files should be deleted about a week after observations. **Given the storage capacity of the cards, GPS observations should not be deleted before the data has been satisfactorily processed.**

The recommended procedure for deleting Jobs is as follows:

- From the Menu, select: Import, then GPS Raw Data.
- The Import GPS Raw Data dialog opens.
- If necessary change drive and directory to the one containing the raw data (usually E:\Geodb\.
- The dialog box will list the jobs on the PC-card. The listing indicates the job name entered in the receiver before the observation and the Sensor ID (receiver serial number) eg D13502-1-0580, where the first 8 characters are the job name and the last four characters the Sensor ID.
- Highlight the job/jobs.

- Right click.
- Select: Delete
- Confirm File Delete sheet opens.
- Select: Yes
- Jobs will be deleted.

4. BASELINE PROCESSING

4.1 Overview

This section provides a guide for editing data if it was not edited when the data was imported. The user is taken through the steps of processing the baselines, analysing and assessing the results, reprocessing of unsatisfactory baselines and export of data for adjustment.

The project window allows you to display the contents of a project by using the different tabbed views that are available. Click on the appropriate tabs below the window to select the different views.

4.2 Editing Data

Point Ids and antenna heights should be checked and if necessary edited during the data import procedure, however if necessary they can be edited before processing. In addition, antenna types and measurement types may be edited before processing if necessary.

4.2.1 Editing Point IDs

The point Ids may be edited as follows:

In the Project window, View/Edit tab:

- Right click on the point to be edited.
- Select: Properties.
- The Point Property Sheet appears.
- Edit Point Id
- Click OK.

4.2.2 Editing Antenna Information

The antenna information may be edited as follows:

In the Project window, View/Edit tab:

- Select the Data-proc tab
- Right click on the appropriate point ID in the left window.
- Select: Properties.
- The Interval Properties (Track) Sheet appears.
- Edit Antenna Type, Height Reading & Measurement Type as appropriate.

- Click OK.

4.3 Initial Coordinates

To prevent systematic errors in baseline processing, the reference point (starting point for baseline computations) must be known within about 20m, and preferably they should be more accurate, in the WGS-84 coordinate system. This is the coordinate system of the GPS data and is used for processing of baselines. GPS baseline processing should always start from a control point with known coordinates of the highest possible accuracy obtainable, ie an existing first or second order control point with published coordinates or a newly established control point with adjusted coordinates. Base line processing should proceed through the network working from a known point to the unknown points.

4.3.1 Entry of Initial Coordinates

In the Project window, View/Edit tab:

- Right click on the point to be edited.
- Select: Properties.
- The Point Property Sheet appears.
- Change Point Class to: Control.
- Enter: WGS 84 Latitude, Longitude & Height (ensure that N & E)
- Click OK.
- The point symbol should change from an open square to a solid triangle.

4.4 Baseline Processing

4.4.1 Selection of Data for Processing

Select the Data-proc tab to switch to the Data-Processing View. A list of all observation intervals and a graphical representation of the observation time for each interval will be displayed.

A reference point (point with known coordinates) must be selected and the relevant rover points for that period of data must be selected. This data is processed and then data from subsequent reference points will in turn be processed.

- If the cursor indicates Rover, when in the graphical window, follow the next three steps to change it to Referen (Reference).
- Right-click on the background of the graphical window.
- Select: Select Mode.
- Select: Reference.
- The cursor indicates Referen.
- Click on the horizontal bar for the first Reference point.
- The colour of the Reference interval changes to red.
- Right-click on the background of the graphical window.

- Select: Select Mode.
- Select: Rover.
- The cursor indicates Rover.
- Click on the horizontal bars for all the Rover points to be processed.
- The colour of the Rover intervals change to green.

After selecting all rover intervals the data is ready for processing.

4.4.2 Processing

To commence processing:

- Right-click on the background of the graphical window.
- Select: Process.

A progress indicator will be displayed.

After completion of the processing, the display will switch to the Results-View. All rover points will be listed together with the coordinates, quality and Ambiguity Status. The points for which Ambiguity Status is yes are automatically selected.

5. ASSESSMENT OF RESULTS

5.1 Ambiguity Status

The SKI-Pro software uses the Ambiguity Status as the indicator of the quality of the baseline solution. It is particularly important for baselines up to 20 km with relatively short observations, which we refer to as Rapid Static GPS. To achieve accuracies at the centimetre level, the determination of the integer number of cycles between the satellites and the GPS Antenna must be successful. How well this has been achieved and the expected confidence in the results are indicated by the Ambiguity Status. There are four possible Ambiguity Status indicators from SKI-Pro baseline processing as follows:

Ambiguity Status	Indicates that:-
yes	The determination of the integer number of cycles between the satellites and the GPS antenna was successful, i.e. the baseline calculation appears to be correct. **Store the data**
yes*	The result should be treated with caution. **Analyse results and consider reprocessing or reobservation.**
no	The ambiguities could not be resolved. **Analyse results and consider reprocessing or reobservation.**
?	No attempt was made to resolve the ambiguities.

If the Ambiguity Status is other then yes, you may further analyse the data by viewing the Logfile. Please refer to the On-line Help for more information about the Logfile. See *5.3 - Advanced Topics – Detailed Analysis of Results* below for information about viewing the Logfile.

By default, ambiguities can only be resolved for baselines up to 20 km. For longer distances the ambiguity resolution becomes unreliable. To achieve good results on baselines longer than 20 km you will need to observe for longer periods of time e.g. 2 hour or more.

The Ambiguity Status is an indicator of the quality of the baseline processing results, however the final decision on the quality and suitability of the baseline solutions is made after adjustment.

5.2 Storing the Results

To store the results:

- Select the baselines or points to be stored in the Results-View screen. Normally all baselines for which the Ambiguity Status is yes will be selected by default.
- Right-click on the background of the graphical window.
- Select: Store.

To confirm that baselines have been stored return to the Results-View and check that the Stored Status for points or baselines is **yes**.

Alternatively, :

- Select: View/Edit tab.
- Right-click on the background of the graphical window.
- Select: Graphical Settings.
- Select: View tab.

To confirm that baselines have been stored make sure that GPS is checked in the data window.

5.3 Advanced Topics – Detailed Analysis of Results

If the Ambiguity Status is other then yes, you should further analyse the data by viewing the Logfile and residuals. Satellite tracking and processing information can be viewed in this way. Note that the Logfile contains a great deal of information, most of which is somewhat confusing. The tracking information and residuals are displayed in tabulated lists rather than a graphical display which does not make for simple analysis.

The analysis of the tracking and processing information and the reprocessing of baselines is a tedious and time consuming process and may not always produce better results. It may still be necessary to reobserve many baselines where the ambiguities are not resolved.

There are no definite rules for the selection of data for reprocessing. Successful analysis of data and reprocessing is a matter of experience. The skills can only be acquired with practice and experience over a considerable time. With experience you will learn to recognise the most important indicators of poor data and the appropriate techniques for reprocessing. However it must be emphasised that not all data sets can be reprocessed to provide a better result and some reobservations must always expected.

5.3.1 Viewing the Logfile

To view satellite tracking information and other processing information:

In the Results menu:

- Select: Logfile.
- The Logfile appears in the right window.
- Right click inside the Logfile display.
- Select: Configure.
- The Logfile Configuration Sheet appears.
- Click Select All.
- Click OK.

The full Logfile will be displayed. Scroll down to view the desired information such as SATELLITE INFORMATION (number of epochs for each satellite on L1 and L2, phase and code), ELEVATION/AZIMUTH (the elevation and azimuth of each satellite for each epoch together with the PDOP and GDOP.

This information will provide a guide as to which satellites have cycle slips and possibly which data should be disbled prior to reprocessing.

Satellites without L2 data, those with breaks or at low elevations may be considered for disabling.

Periods with high GDOP (>8) are unlikely to give a good solution and may need to be deleted from the baseline processing.

5.3.2 Viewing Residuals

To view the baseline Residuals:

In the Report-View:

- Right click on the baseline.
- Select: Compute residuals.

To display the residuals:

- Double click on the baseline in the Tree-View
- In the Tree-View, select: Residuals.

The phase residuals should be examined to determine which satellites have noisy data and may be considered for disabling.

Large residuals on all satellites could indicate a problem with the reference satellite and it could be worth disabling the reference satellite and reprocessing.

5.3.3 Viewing Graphical Satellite Information

To obtain a graphical view of satellite tracking information:

In the Data-proc view:

- Right click on the linebar representing the observation.
- Select: Satellite Windows.

This will display each satellite tracked for that particular point but it does not indicate if it is L1 or L2 data and does not indicate short breaks in the data, accordingly the graphical display is not considered a particularly valuable tool for analysis of the data quality.

The main value of the graphical view is for disabling or enabling all or parts of satellite data prior to reprocessing. (see *5.3.4.2 - To Enable/Disable Satellites by Selecting Satellite Windows* below)

5.3.4 To Enable/Disable Satellites

There are two ways to enable or disable satellites. They can be disabled through the Processing Parameters option or by selecting Satellite Windows.

If using the Processing Parameters approach, the entire data set for the selected satellite will be enabled/disabled for all observations in the current processing set. Accordingly this is generally not the preferred option.

If using the Satellite Window approach, all or a portion of the data for a particular satellite may be selected and enabled/disabled as required. This is the preferred approach in most circumstances.

5.3.4.1 To Enable/Disable Satellites using Processing Parameters

To enable/disable a satellite:

In the Data-proc view:

- Right click inside the display
- Select: Processing Parameters.
- The Configure Data-processing Parameters Sheet appears.
- Check/uncheck the relevant Active Satellites.

5.3.4.2 To Enable/Disable Satellites by Selecting Satellite Windows

To enable/disable a satellite or portion of the data for a satellite:

In the Data-proc view:

- Right click on the appropriate observation interval.
- Select: Satellite Windows.
- A graphical view shows all the satellites of the selected observation interval.
- Right click on the background.
- Select: Window (Include) or Window (Exclude)
- Drag a rectangle over the observation period to be included or excluded.
- Select: OK.
- The intervals that are to be excluded from the processing are marked as blank spots.
- Several windows may be selected for a satellite.
- Satellite windows may be removed by right clicking on the appropriate satellite and selecting the appropriate option.

5.3.5 Reprocessing Baselines

As a general rule it is suggested that only one or two changes are made for each reprocessing run so that the effects of the changes can be determined.

Reprocess the relevant baselines after enabling/disabling satellite data and analyse the results again.

If the changes do not result in any improvement to the baseline, it may be appropriate to reverse the changes before making further changes and the next processing run. However as a general rule it is usually best to disable satellites with very little data and many breaks as they will not contribute to a good solution.

When a satisfactory result is achieved, save the data.

Caution, do not disable so much data that there is insufficient for a reasonable solution.

For baselines where the ambiguities are not resolved satisfactorily it will probably be necessary to undertake reobservations unless you have sufficient alternative baselines to provide a proper solution in the adjustment with the required level of redundancy.

If the GPS teams are still working in the area it may be appropriate to do the reobservations immediately or it may be better to wait until after you have completed an adjustment of the network because there may be other points nearby to reobserve. Consider the logistics, availability of resources and the workload in making a decision.

For reobservations, if possible ensure that they are done when there are a maximum number of satellites available. Consider what obstructions there are at the site and take any possible steps to minimise their effect by careful timing and/or clearing. Always observe for longer than the minimum time.

5.4 Export of Data for Adjustment

Baseline processing results must be exported from SKI-Pro in ASCII format before they can be incorporated into a GeoLab adjustment.

To export the baseline results:

- From the Menu, select: Export.
- Select: ASCII…
- Select: Settings…
- The SKI ASCII Export Settings sheet appears. The Settings menu is divided into several tabs – General, Point and Baseline.
- Configure each tab as follows:
- **General tab**
- File Type: Baselines
- Coord. Type: Cartesian
- Coord. Class: All
- Sort by: Point ID
- Rounding: 0.0001
- Include: Keywords (checked)
- Header (checked)
- **Point tab**
- Point Type: All
- Nothing checked

- **Baseline tab**
- Baseline Type: Static
- Covariance (checked)
- Epoch information (checked)
- Click: OK
- Select: directory to save in
- Enter: File name
- Ensure that “Save as type” is “SKI ASCII file (*.asc)”
- Click: Save

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

6. NETWORK ADJUSTMENTS

6.1 Overview

To determine the final coordinates of the points observed with GPS, all the 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 SKI-Pro software provides a least squares adjustment facility but Microsearch GeoLab is the preferred program.

6.2 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.

6.2.1 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 *13.1 – Licence Transfers* below for details.

6.2.2 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 in February 2002 (Purchase ID 27658375), one of these copies was purchased for Coast & Geodetic Surveys Department, NAMRIA. A further copy was provided for PIO1 after the adjustment training in September 2002 (Purchase ID 18768422). The licences include a licence for Microsearch GeoLab Explorer, a utility program that enables the user to access the GeoLab binary files.

Advice from Microsearch indicates that minor updates are provided free of charge but for major upgrades the cost depends upon how long since the original purchase or the last upgrade.

A major upgrade is expected around December 2002.

In November 2002, Microsearch announced the introduction of "Subscription and Support Packages". Under the "Subscription Package", all upgrades are provided free of additional charge for the subscription period. Under the "Support Package", Microsearch provides free technical advice on adjustment problems. The two packages may be purchased either alone or together. Discounts apply for purchasing second and subsequent packages. Full details of the packages can be found on the Microsearch website.

By purchasing such a package, it is possible to budget for and ensure access to the latest software upgrades and support.

6.3 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 of Microsearch has indicated (10 June 2002) that they are 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 which is also 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 which the user is encouraged to explore and use when necessary.

7. INITIAL ADJUSTMENT RUN

7.1 First Steps

Create an appropriate directory or directories under C:\GeoLab 2001 Projects\ for processing of network data. **Data must not be stored or processed in the Program directories.**

Copy the SKI-Pro ASCII baseline processing results file to the selected directory.

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.

7.1.1 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 the vertical. 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 available. 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 *5.4 - Export of Data for Adjustment* above, initial coordinates will be provided for all points, however when exporting data from the Trimble Geomatics Office baseline processor this is not necessarily the case and it may be necessary to generate initial coordinates as part of the adjustment process. For this reason it is suggested that this option is always set.

To set these options:

- 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

Exit from Microsearch GeoLab.

7.2 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.

7.3 Network Setup

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

7.3.1 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 PASTR_01 for the first run, and PASTR_02 for the second run etc.) See *11. – 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.

7.3.2 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: Leica SKI
- Click: OK
- Station names should not be longer than 12 characters, so it shouldn't matter which option is checked.
- Extension: *.ASC
- Click: OK
- The GPS data type will be displayed as Leica SKI.

7.4 Network Data

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

7.4.1 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 file or files.
- 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: PASTR_01.APX (coordinate listing); PASTR_01.GPS (GPS baselines with variance covariance matrices {VCVs}); and PASTR_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.**

7.4.2 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 values, usually the published NAMRIA WGS84 values for certified existing control points, or the WGS84 value from a previous adjustment.
- 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

7.4.3 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.
- 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

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 which may necessitate restoring the GPS Environment screen from the bottom of the computer screen and repeating some of the above steps to get the adjustment to run.

After adjustment, the list file (PASTR_01.LST) is displayed and the Network Processing Completed sheet is opened. To display the network:

- Select: required drawing scales
- 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 be backed up. The list file should be closed before proceeding to the Utilities menu.

7.5 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:

7.5.1 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.

7.5.2 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 *12 - 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 (PASTR_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.

7.5.3 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 *11. - 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 *8. - ANALYSIS OF RESULTS* below).

To copy the active network files:

- From the Menu, select: Utilities
- Select: Copy Active Network
- Copy test 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 PASTR_02.IOB
- Click: Save
- Displays a message indicating the new active network name and path.
- Click: OK

7.5.4 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 *7.5.2 - 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 (unless a GeoLab2 file)
- 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 PASTR_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.

8. ANALYSIS OF RESULTS

8.1 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 may wish to backup the adjustment files as follows:

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.

8.2 The List File

The results of the adjustment are written to the list file (PASTR_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:

8.2.1 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.

8.2.2 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.

8.2.3 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.

8.2.4 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.

8.2.5 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).

8.2.6 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.

8.2.7 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). 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 *7.1.1 – 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 *7.1.1 – 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.

8.2.8 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.

8.2.9 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.

8.2.10 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 *7.5.1- 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.

9. 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 *7.5.3 - Copy Active Network* above subsequent runs should be made with a new set of active network files. Follow the instructions in 7.5.3 above to create the new active network then comment or restore measurements as described below.

9.1 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.

9.2 Next Adjustment Run

After commenting/restoring observations you will be ready to re-run the adjustment. Repeat the steps in *7.4.3 - 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 *7.5 - Utilities* above to compute the FGCC orders and archive the adjustment before analysing the output as suggested in *8. – 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.

9.3 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.

9.4 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 published NAMRIA WGS84 values for certified existing control points, or the WGS84 value from a previous adjustment for other points.
- 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.

10. 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 point 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 *7.3.1 - Open Network* above). The file should have the extension .COB (Classical OBservations), eg. PASTR_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 *10.1.3 – Format of the COB File* below.

10.1 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:

10.1.1 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.

10.1.2 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.

10.1.3 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
```

10.2 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\Philippines PIO1\San Miguel\San Mig-13.opt
#include C:\GeoLab 2001 Projects\Philippines PIO1\San Miguel\San Mig-13.apx
#include C:\GeoLab 2001 Projects\Philippines PIO1\San Miguel\San Mig-13.gps
#include C:\GeoLab 2001 Projects\Philippines PIO1\San Miguel\San Mig-13.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 is suggested that the ***PA-Traverse Calculator Software*** is used to generate approximate coordinates. Before running the ***Traverse Calculator*** it will be necessary to generate PTM coordinates from the previous adjustment run using the Transform Coordinates feature from GeoLab (see *12.3.2 - Transformations to PTM (Geographic to Grid)* below).

It is suggested that the slope distances are used, unless there are very steep sights. The PTM coordinates generated from the ***Traverse Calculator*** must be transformed back to WGS84 Geographic Coordinates. Enter the PTM coordinates into a GeoLab format file and transform, use some known control values as a check on the transformation process.

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 *7.5.2 - Pack IOB (Archive)* above and then analyse the results.

10.3 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.

11. 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 *7.3.1 - 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 *7.5.2 - 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 *7.5.4 - 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 *7.5.3 - Copy Active Network* above for detailed steps and refer to the *GPS Environment for GeoLab User Manual* section 6.3.4.

12. TRANSFORMATIONS & EXTRACTING COORDINATES

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

12.1 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) 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.

12.2 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 Second Order 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 for LAMP transformations:

12.2.1 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.

12.2.2 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.

12.2.3 7-Parameters

Enter the 7 transformation parameters. Normally you will be transforming from WGS84 to PRS92 so will have to enter the transformation parameters from page 9 of *The Philippine Geodetic Network* brochure (the Blue Book) published by NAMRIA. **(Take care to enter the correct signs.)**

These values should be saved and stored in the Microsearch\GeoLab directory for future use (eg. WGS84-PRS92.7PR). 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. These values should also be stored for future use (eg PRS92-WGS84.7PR).

12.2.4 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.

12.3 Transformations to PRS92 and PTM

12.3.1 Transformations from WGS84 to PRS92 (Geographic to Geographic)

Note that PRS92 is on the Clarke 1866 Ellipsoid.

The transformation may be from any of the three input options as indicated above, but will generally be from the adjusted network. Note that the binary adjustment files must not be deleted before doing transformations from the adjusted network.

No projection will be selected for the output.

Set up the appropriate data on the GeoLab Coordinate Transformer sheet and the tabbed option pages. When ready, click Transform.

12.3.2 Transformations to PTM (Geographic to Grid)

In transforming to Philippine Transverse Mercator (PTM) grid coordinates, the input data may be either a text file or an adjusted network. If an adjusted network, the 7-parameter transformation to PRS92 from the adjustment datum (WGS84) must be included.

To transform to PTM grid coordinates the following parameters for the individual zones must be stored in the appropriate file within the GeoLab directory. Note that they are stored within a binary file that cannot be viewed or edited using a text editor.

TMER	PTM 1	e117 0	n0 0	0.0	500000	.99995	1.0	m
TMER	PTM 2	e119 0	n0 0	0.0	500000	.99995	1.0	m
TMER	PTM 3	e121 0	n0 0	0.0	500000	.99995	1.0	m
TMER	PTM 4	e123 0	n0 0	0.0	500000	.99995	1.0	m
TMER	PTM 5	e125 0	n0 0	0.0	500000	.99995	1.0	m

The available map projections can be viewed and edited using the Tools/Map projections options. This displays the Select/Edit Map Projections Sheet. From here it is possible to enter new projections or to import from a text file. If the above parameters are not displayed they should be added. The columns are as follows: TMER – Transverse Mercator; Projection Name, Origin Longitude; Origin Latitude; Origin Northing; Origin Easting, Origin Scale; Linear Unit

Set up the appropriate data on the GeoLab Coordinate Transformer sheet and the tabbed option pages. When ready, click Transform.

The grid coordinates in the specified PTM zone are written to the screen and may be printed and/or saved.

13. SOFTWARE LICENSING

As indicated in *6.2.1 - 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:

13.1 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. 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
- 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