Introduction

SMS provides facilities for Level Management, designed to cater for the needs of the Surveyor in all aspects of levelling. It is a model of day to day field and office activities that include data collection, processing, computing and management. These facilities are comprehensive and offered to the user in a friendly and multi-tasking environment. It equips the Surveyor with tools and means to faster job execution, and reduced costs by cutting down the duration of projects to essentially the period of field activity.

Data Collection

The process of data collection involves the use of electronic field book. This is a data base with interface modelled on standard design of a level field book. There are primarily three options based on instrumentation and data format. These are:

- Digital Levels/BF
- Optical Levels/BBFF *
- Standard Levels/BF

Digital Levels/BF

These levels come with provisions for plug-in memory module and data terminal. In normal use, input through this instrument is digital and the procedure is to transfer the raw data file to field book. There are instances, however, where observations and recording may be manual but in both cases the field book provides a database for editing the raw data file of field observations.

In this category also are optical levels with attached parallel plate micrometer, that are common in precision levelling. However, with the introduction of digital levelling they are no longer the obvious choice. Nevertheless, they remain useful instruments and an alternative in many survey organisations.

Regarding the field book, both instruments share the same format with observations to a tenth or hundredth of a millimetre.

Optical Levels/BBFF *

A typical instrument is Zeiss Ni 007 with built-in parallel plate micrometer, robust in design and able to withstand vibrations. Observation consists of two scale readings on the staff. As a result, the field book is unique in providing for four input readings for each set-up. A common source of error is incompatible scale readings. To guard against this mistake, there is an automatic check on staff readings by comparing the difference between scale readings and instrument constant and informing the user where this exceeds 0.5mm.

Besides Zeiss Ni 007, the field book caters for any other instrumentation or data capture that is based on double scale readings, **BBFF**. To assist this flexibility, there are two additional fields for each observed record: the scale constant and exageration factor. The scale constant is the difference between the scales and the factor divides any observed height difference to obtain the correct height difference. These values always hold default information that at first instance are either 6.06580 and 2.0, for the Ni 007, or the last correction.
The level of flexibility is such that this information can vary between set-ups, allowing the use of different instruments in one project.

*However, the use of this instrument has been virtually overtaken by the digital level. This facility is now available on request.

Standard Levels/BF

This is instrument of choice in many situations where the survey is of low order accuracy. The field book has the same appearance as in the first category. However, in conformity with instrument resolution, the input field requires readings to a millimetre.

Trigonometric Levelling

This facility is part of 3-D Traverse. It is best therefore to refer to this section. However, in traditional situations these observations are part of a triangulation scheme and the practice is to obtain the height differences and then compute the network. In this respect, provision exists for such networks but it will require the transfer of height differences to the field book.

General Characteristics

Apart from the specific details above, each field book has the following in common:

Sorted Data Set

The field book enforces a sorted order in the data set of survey observations. This preserves the link between level set-ups in the data base irrespective of the order of input or observation. This facility provides standardisation, allows freedom and flexibility when gathering survey data. It is a mirror of situations where it is not possible to continue with the normal order of survey so that gaps exist in the network. In such circumstances the survey will continue at a later stage and when complete, it is normal to sort the entire data into a suitable order before computations could begin.

Intermediate Sights

Each field book has a command button that inserts a window for intermediate sight data collection. This is a relatively small sized field book but with similar facilities. It sorts the data set into alphanumeric order irrespective of the sequence of input or observations. It also preserves the link and relationship between backsight readings and the intermediate data set. This makes every set of observations unique and independent so that it is possible to store and process observations from more than one intermediate set-up, involving the same backsight station. It is a useful facility where the survey involves large number of observations, for example in building survey, and it is not possible to complete the work because of time or obstructions. When the survey continues at a later stage with new instrument set-up and backsight observations, a new field book will open for the observations that follow. The previous data set remains in memory but is accessible in another field book by restoring the backsight reading. There is a distinction between level set-up consisting of back and fore sight observations in the network and intermediate set-up that comprises of a backsight reading and a set of intermediate ob-servations. These set-ups are independent and the backsight readings do not have to be the same.

Double Levelling

Double levelling consists of forward and back levelling that may involve one or even all the set-ups in the network. The process of data input into the field book includes scanning the database for any existence of forward observations relating to the current set-up and if it exists to determine the loop closure. The order of data input or survey does not affect this process. At any instance of double levelling, a window opens to provide the user with error or closure information. It is important to note that the mean values of reduced height differences will always refer to the first direction.

Editing and Data Formats

Each input field has a format to accept valid data only. Station names should start with a letter and not exceed five characters. In the case of digital input where station names are point numbers, the transfer process includes insertion

of 'P' into the name string to conform with format. Therefore, point numbers should be in the range 0-9999. It is advisable to maintain the same length of string for names throughout the data set. As an example, point P1 should be P01 and so on. This is to ensure proper alphanumeric order when listing stations. Staff readings can be negative to allow invert readings such as soffit levels. The integer part of the input field can accept up to three characters, enough to cater for most tape drops.

Editing of input field is with the same ease as in a text editor. The tab button or mouse enables movement from one field to another. The Revert command restores the previous input while Save (Enter) reduces the observation, computes the cumulative height difference and then saves the entire record to memory. Each input field has a history list window consisting of previous entries. It is also a facility that allows users to recall previous entries or undo corrections. There is no provision for duplicate records in the data base but these facilities permit easy modification of existing observations. It is possible to delete a record in the data base. The process involves erasing a key field such as station name from the input line and then saving the record to memory. Since every data field has a format, this action will result to rejection and deletion of the record from data base.

There is a remark section, a memo field for each record. It is a mini text editor with facility to scroll, cut, copy, paste, find and replace. Though the size of window may be small, the amount of memory is enough for entry of relatively large textual information.

Utilities

A standard calculator and calendar are available on command from program menu. So is full use of Windows™ clipboard for import or export of text and bitmap files, through text and graphic editors. As typical in a multi-tasking environment, it is not necessary to end input session to use these facilities.

Digital Input

This is a facility to transfer field observations from digital levels into the field book. The procedure requires only the name of the raw data file including drive location. It then loads the entire observations including intermediate sights, if any, into the data base. This transfer involves only the observed quantities, back sight, intermediate sight and fore sight, and respective stations. The process also performs the necessary reductions and summation of height differences as in other cases. The advantages are as follows:

- It is possible to use default values of BM/TBM during field observations without affecting the process of Office computations of the network.

- It also follows that it is not necessary to reset the instrument with new starting height values at the beginning of every run. The surveyor could therefore choose to continue more rapidly with observations.

- There is no use of feature codes and more memory is available for actual observations.

There is no limit to the number of times digital transfer of data can take place. If the observations already exist in the field book, the new input will overwrite previous observations otherwise it will add to existing records. This enables use of digital levels for field checks that may involve repeat or extended observations but without the need to edit previous records. Furthermore, where the network is large, this facility allows part computations and analysis while the survey is still in progress.

Methodology

It is important, at this stage, to consider correct approach to data collection. The facilities in the field book are comprehensive, flexible and designed to assist survey process in a very efficient manner. Therefore, the Surveyor should take these functions into account, *before* starting a survey. This is necessary to avoid duplication of effort and save costs.

The points to note are as follows:

- A survey can start from and close at any point. The order or direction of observations does not affect the result of computations. What is required is that the network is comprehensively observed and open runs, if any, should start from either a node or fixed station.
- No feature codes are required. All observations are one single data set. All stations should have <u>unique</u> point numbers or station names. Therefore change points must not have the same identifier. The Surveyor should maintain an accurate network diagram.

- Editing of the field book would be necessary if there are errors in station names and therefore inaccurate description of the network. However, if there are no such errors then computation of the network should begin. Renaming points to station names is easier during editing of stations or deletion of change points from station list. This is because there is only one instance to correct. In the field book, the point might be a node and require corrections for every instance of observation.

Control Records

There is a data base for control records consisting of station name, height and a memo field for station description. Station names have the same format as in the field book. Height values can be negative and up to six places in decimal, however, the integer part of the field should not exceed four characters. Facilities exist to edit, add and delete records. Furthermore there is a list window to review all records in a tabular and ruled format. The data base should include any control station that is likely to be of use in the execution of the project. During processing it provides information about the fixed status of stations in the field data set before any computations and adjustment.

Station Description

There is provision for graphical description of stations as part of the control records. It requires the use of graphics editor to prepare a bitmap file in station name, for example 'P1.BMP', located in the directory of data base. This data is available like any other fields in the record. It defaults to a building description, if no file is found.

The quality of representation depends on the output device and graphics package available. It is now common to take photographs of stations to assist descriptions. There is also a trend towards desktop image processing. A photo-quality is possible simply by scanning these images into standard Windows™ bitmap files, *.BMP, of 256 or more colours. True colour images of 24-bit formats should be converted to 16-bit to reduce size of data file.

To avoid significant data compression or distortion of original image, the size of any drawing or image should be 200(width) x 160(height) pixels.

Image Editor

SMS offers integrated bitmap file editor and drawing program to specifically assist in station descriptions. It can also be used to edit and review graphic files of any size, in standard Windows™ format of 8-bit or 24-bit, true colours. It allows automatic realisation of colour palettes and full facilities to copy or paste files from clipboard.

Using the editor is a simple process of installing the canvas, drawing surface, and selecting from the toolbar:
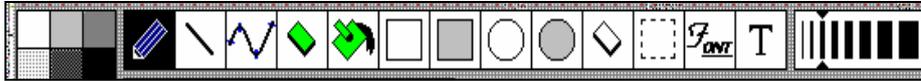
The left most tools represent the colour palette. The next three options are free form drawings, straight lines and curves by short line segments. All mouse selections are based on the left button except for the tools in green, brush and fill tools for the background colour. These require selections from right button. The rest of the tools are obvious. The size of the eraser and brush depends on current pen thickness. Images are sized automatically when loaded into the canvas. However, there is option to stretch or pad images.

Colour settings for the Windows™ screen should be *16-bit* or *256* colours, and through the Control Panel or Program Manager. This will also ensure that colours are realised in the on line manual.

Header Information

Header records provide administrative information on each project. It centres on the reference job number and sub-titles under the project. There are two data bases to serve this purpose. The first one goes under the filename '**SMSIDX.SYS**' and is the root of data base management. It is an index that holds all the job numbers and related information such as date, details of job and client.

The second data base has a file name '**&####.LVS**' consisting of the job number and extension name. It contains details such as title and date of survey, surveyors' names, instrument type and manages all the sub-schemes under a particular project. In a monitoring project, each visit constitutes a scheme and in other cases any independent survey under the project name or job number. There are therefore no separate files for sub-titles and the potential size of the data base can be very large. It is advisable to select a location in the computer hard disk. Re-location is easy since it requires copying only one file.

The interface for entering and modifying existing records has a familiar quality to the field book. The key input field is in either case the job number or title of survey.
Memory considerations limit the capacity of each data base to 16,380 records. In practice, the actual number of elements will depend on the size of each record and available RAM. However, given an average of 4 megabytes in RAM, the field book can hold up to 2000 set-ups. It is therefore not likely that users will encounter any memory limitations. Furthermore, there is a recovery mechanism if memory is not sufficient.

Processing

The software can cope with most types of network and requires three main sorting procedures. The first of these involves combining all observations from each instrument type into one single data set. If there are duplicate set-ups, observations with Digital Levels and Ni 007/BBFF will take precedent, in that order. Also at any instance of double levelling, a mean value of height differences will replace the first observation. The process identifies any control points in the data set by access to records in the control data base. There is a print button in the list window to provide a hard copy of the reduced data set.

Node Identification

The next stage involves identification of nodes in the data set and establishing inter-node relationship. These are the number of set-ups between control stations or nodes, direction of runs, inter-node height differences and computation of provisional node heights. It will also classify open runs, if any, that do not end on a node or control station. There is an alert if this condition exists and furthermore an asterisk against such stations for easy identification during listing.

There is no restriction on the type of network and surveyors should ensure that no gaps exist in the data set. The software will process and compute only one network from the data set and present results in two list windows. One lists the nodes in the network, the number of backsight or foresight observations to the station and provisional node heights. The second window lists the node-to-node relationship in form of direction of run, number of set-ups and node height difference. These two windows also have print command buttons and provide a description of the network that should agree with the surveyor's own diagram.

Loops and Closures

It is always important to analyse and check for any errors in a network. Forming condition equations from the reduced data set is one of the most reliable methods. This is in form of independent loops and closures in the survey. There are as many cycles as the number of condition equations. The process of forming these loops involves traversing the data set. The selections are always subjective and may differ from cycles that the surveyor might choose from network diagram. However, they represent condition equations and the closures offer means to locate errors and assess the network.

Besides internal checks on the network, this process also caters for external consistency such as observations between control points. However, in this case the loop will consist of observed and derived values. As an example, consider a survey involving two control points, starting from A and ending at B. There are two values to consider; A - B the known height difference and A' - B', observed difference. This can form a loop A - B B' - A' whose closure is the error in the survey.

These methods ensure a comprehensive check for any network. Gross errors are easy to identify. For the Digital Levels, mistakes come mostly from station names and

point numbering. It is *advisable* to pay particular attention to this common source of error to minimise editing.

Results are in two list windows. The first one lists all the closures in the network, each assigned to a loop number. It has an input field for a loop number, a print and list command. The latter opens the second window to list or print elements of any selected loop. Any number of loops may be processed.

Computing

There are three stages in the computing process consisting of least squares adjustment, inter-node computations and determination of intermediate heights. The first stage depends on whether there are nodes in the data set. Estimation is by variation of parameters, using the provisional heights computed during node processing. It assumes that the variance of each measurement is proportional to the number of set-ups and that no correlation exists between each observation. Therefore the co-factor matrix is diagonal and consists of number of set-ups for each reduced observation. This is sound in most situations and results are identical irrespective of the standard error per set-up. An alternative approach would be to relate the weight inversely to distance. However this information is not always available, even with the digital level. Overall, the basis for estimation is to resolve any inconsistency in the network so that the rest of the computations could begin.

Inter-node calculations involve taking each run, computing the heights of interior stations and distributing any error proportionally to the number of set-ups. This stage also includes open runs and intermediate heights, if any.

From the user's perspective, the entire computation process is a single event and when complete, results are available in program menu.

There is no limit to the size of observations for least squares adjustment. However, in practical terms, it must be within the available RAM. As a guide, 32 megabytes of free RAM is enough for a network of more than 350 runs and 250 nodes. If the average run consists of about 10 set-ups, then the overall size of the network could exceed 3000 observations, excluding any intermediate sights. It is not likely therefore that users will come across memory limitations, except if several applications are running at the same time.

There is mechanism for recovery in case memory is not sufficient or if the normal matrix is singular. The program does not terminate but alerts user to the situation.

Management

There are a number of options under this facility. Generally, they centre on collation of results, editing and presentation to such a standard that the use of external software would not

be necessary. These facilities are extensive and includes monitoring, longitudinal and cross-section profiles. Other utilities are surveyors reports and memos to assist communications.

Results

Two data bases, station list and current visit, contain the results of computations. The station list consists of heights of all stations in the survey and change with every new computation. The current visit is a copy of the station list but with additional fields in each record consisting of easting and northing. It includes an interface with editing facilities and a list box. The options available to the surveyor are:

- Deletion of change points from station records.

- Addition of easting and northing co-ordinates to station records.

- The use of first data base for results of survey and the second for storage and presentation of related three-dimensional information.

The contents of current visit data base do not change once initialised with default or edited values. However, if the user selects <u>Overwrite</u> from menu, the data base will revert to a copy of the results of survey.

Monitoring

Monitoring results are deductions of movement based on comparing current results with earlier ones that represent the base and last values. For this reason, there is a data base each for base and previous visits that is identical to current visit. The initial values of base and previous visits are copies of the current visit at the time of first visit. Editing of base and last values would be necessary only if stations are lost between visits or if there is relocation of job data base that impedes access to original information.

The base and last visits are determined by the software from the order of precedence in the job data base. There is provision however, to overwrite contents of either data base with any selected visit. This flexibility allows the surveyor to generate a custom result covering any range of visits.

Monitoring results are in two forms, Results and Trend Analysis.
Results refer to movements relating to a particular visit. Trend Analysis are such results for all the visits in the scheme. Each time a result is generated, it goes into a stand-alone database, 'JobNumber.TRD', for Trend Analysis. It is possible to overwrite existing results but this is a two-stage process that requires generating

results for the next visit in the scheme, to ensure that the rest of the database is up date.

The data base is self-updating. Search routines use station names in base visit as key fields that must exist in reference records before any deductions about movements relating to that station, otherwise a remark such as 'N/A' will be entered in the relevant column.

Graphical Presentation

Monitoring results are also available in the form of charts and graphs to represent results during a visit and trends for each station in the scheme.

Results are in form of bar charts that represent the heights of each station for the base, last and current visits. The emphasis is to illustrate movements relating to base and last visits. Hence, each station chart has a vertical scale of 3:1. The charting range is from -10mm to +10mm.

Trend Analysis is in form graphs, heights of stations against visits in the scheme. The base height is the datum for each graph and illustrates the movements or trend for each station. The vertical scale is 3:1 and charting range is from -10mm to + 10mm. Station heights outside range or not available during the visit are ignored.

Profiles

Longitudinal and transverse profiles are common applications of levelling in civil engineering. They provide earthwork information to assist cost and project management.

Methodology

The advent of Digital Level introduces a dynamic dimension to data acquisition. Traditionally, it is common to peg out the centre line and cross-section chainage before commencing levelling. While this practice is still advisable, this information can now be acquired in the course of survey. Furthermore, the interval between the chainage points need not be equal. The survey process may be enumerated as follows:

- Commence line levelling to and along the centre line.
- Set up on the centre line and between staff points.
  - Back sight to point on centre line and cross-section.
  - Pick points along the cross-section as intermediates, only.
  - Name points left/right of centre line as 1xxx/2xxx, respectively.
- Select salient points along the longitudinal profile.

Data Structures

Survey observations and results are common data set in the data base. After computations, every run will have default profile information. Similarly, every station in a network is initialised with centre-line details and intersight observations for the cross-section. Building a profile involves designating a run in the network as a profile source. A copy of this information is created in the data base under the specified title. It can then be edited, if necessary without changes to source data. It is also unaffected by changes in the source data. However, a profile can be removed or re-selected into a list. These facilities are flexible enough to admit reduced data from other instrument sources such as theodolites.

Interface

The data base has the interface of a spreadsheet and includes specifications for design, gradient and formation level. The spreadsheet is continually scanned during input process and reductions computed each time to provide cut or fill information. A Refresh option saves contents and inserts any intersections, points of correspondence between design and profile. It also provides access and correlates cross-section information.

Editing

The spreadsheet features data-awareness through data validation, integrity and correlation. As a result, editing is minimal. If all the stations in a run of levels are part of the required profile, then no editing is required.

The data set is sorted in order of chainage and maintains the relative chainage after deletions. A row of data is deleted if any input cell is blank. Refresh option performs sorting and re-initialises the data set to a reference zero chainage. It is therefore not required to modify cell information as result of deletions.

Input Modality

Input should be appended to the end of the spreadsheet. The size of the data base is 150 points, to conserve memory, but can be set higher if necessary. Design information, gradient, can vary along the profile. This should be in a progressive order, in line with chainage. Also, the data base should be updated or refreshed between settings. Changes in the spreadsheet are effective only from the last design setting. It is also a facility that locks or protects the edited portions of the database.

Cross-Sections

Cross-section information is available from the input interface of longitudinal profile, for each chainage point. The spreadsheet in this instance also caters for 150 points and includes provision for design specification, formation width and side slopes, 1:S1 and 1:S2.

Input Formats

Side slopes should be entered as S1 and S2 only, while distance format includes a sign, positive or negative, to indicate right or left of the centre line, respectively. Also note that TP, W1 and W2 are *reserved* names for points of intersections only, and not for use. Rename any TP in profile to provide unique reference.

Areas and Volumes

The sections are classified by software as follows:
- Cut

- Fill

- Cut-Fill

- Fill-Cut

This is done each time the spreadsheet is updated or refreshed. It is the basis of Area and Volume computations. There are display fields in the interface to provide this information and changes dynamically with the contents of the spreadsheet.

Area computation is based on the multi-level cross section. However, computations of mid-point areas assume even slope on either side of the centre line. Volume is determined through the prismoidal formula. Cumulative volume is the sum of such volumes across the profile.

Volume determination is possible only where the sections are of the same class. Therefore sections should be inserted at points of intersection, for example between a Cut and Fill section. This technique may be used to carry cumulative volume forward, otherwise, it is initialised between sections of different classes.

Graphical Output

The contents of the spreadsheet can also be presented graphically, on screen and to printer. This information is accurate to scale.

Working Profile

The vertical scale is determined to accommodate the range in height difference and horizontal scale maintains a ratio of 10:1 in vertical exaggeration. However, for on screen graphics this ratio improves to 5:1, and includes a scroll button to span the profile. Output to printer is based on media size of A4, with overlaps and registration of features between pages.

Cross-Section Drawing

The graphic output includes area descriptions. On screen, there is a ratio of 1:1 between vertical and horizontal scales. However, for printer output, this may vary in order to accommodate the range in distance.

Graphic output is of standard quality to meet the requirements in most cases. However, to assist use in other forms, data export is provided by ASCII files. These are formatted as tables to load into word processors, spreadsheets or databases.

Presentation

There is a command button to list the contents of each data base. Inside each list and output window are print and file command buttons. Results are printed in a tabular and ruled format. Header details include job number and date of survey. All printing is in *portrait* and no printer set-up is required. There are page breaks and in case of Trend Ananysis, overlaps between sections to preserve the quality of presentation.

Reports

The process of writing a report involves filling input fields in a record. These include the crew, accuracy and description of survey. It is possible to write more than one report by choosing a new record.

There is also a memo facility from program menu, to pass instructions and mesages relating to any scheme. It is a mirror of clip notes that are normaly attached to job files in the ofice.

Other facilities include a text file viewer to display ASCII files of up to 4 megabytes and a graphic editor suitable for review of bitmap files. A text editor is available to write letters, load or save small ASCII files. There is a summary of header information from program menu.

Quality Assessments

SMS provides quality judgements and assessments in respect of survey projects and deformation information. These are based on statistical principles and applications, such as histograms, normal distribution and standard deviation.

Precision of Points

Survey Instruments are usually quoted at given accuracy or standard deviation. This depends on both the instrument and staff. A common example is Na3003 with quoted accuracy of ±0.4mm and ±0.9mm for the invar staff and conventional fibreglass staff, respectively.
SMS provides list-boxes to select instrumentation as well as any of the quoted accuracies. During least squares estimation, this information is used to compute the precision of height for each node in the network. The height of these points may then be quoted with the given margin of standard error.

Precision in Monitoring

The level of precision is an important factor in deformation surveys. There are categories of height monitoring, from low to medium and high precision monitoring. It is possible to translate and verify these specifications in practice. This requires the correct choice of instrumentation and also design of a suitable network where this standard is attainable. Henceforth, subsequent verifications in each epoch ensure that this criterion is always met.

Therefore, if the precision of height of a point is ±0.1mm at each epoch, for example, the deformation information may be quoted to an accuracy of ±0.14mm. Conversely, if the required precision of any reported movement is ±0.1mm, then the standard error of the height of point should be ±0.07mm.

Assessment Parameters

With the large amount of data acquisition, involving huge networks, it is useful to introduce parameters to assist in overall evaluation of quality and reliability of survey information. It includes graphics as represented by histograms and interpretation of data as samples of population, in terms of Normal Distribution. In this context, therefore, Assessment is defined as a factor, 2.58, of Standard Deviation and provides a 99% margin of probability or deviation from centre of interest.

Error Analysis

In fig 1.0, is a histogram of misclosures in a typical survey. The central interest is the assumption that no errors exist in the network. Accordingly, the misclosures are deviations from this position, as illustrated in the diagram.

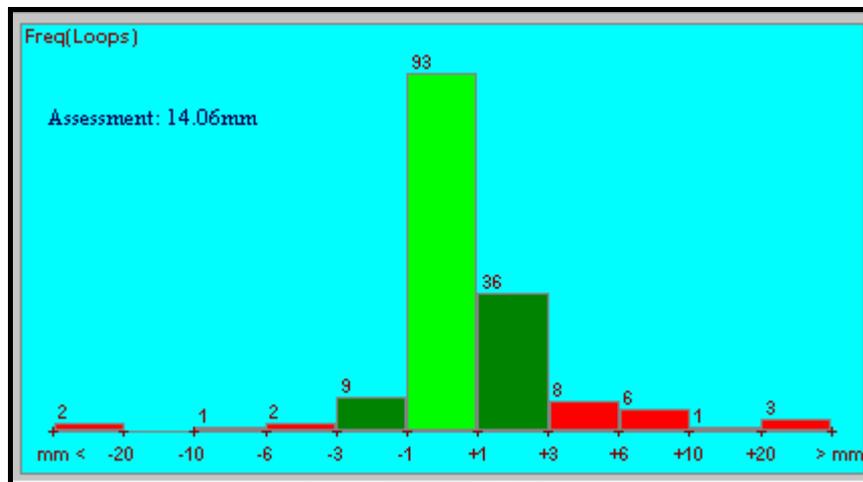The Assessment is ±14.06mm. If this is within specification, then the observations are acceptable.

fig 1.0

Furthermore, misclosures exceeding this tolerance may be considered outfliers and reviewed on the basis of distribution pattern.

Computations Analysis

The same principle applies in assessing the results of a survey network computation. In figs 1.1a and 1.1b are histograms relating to residuals and precisions, respectively.
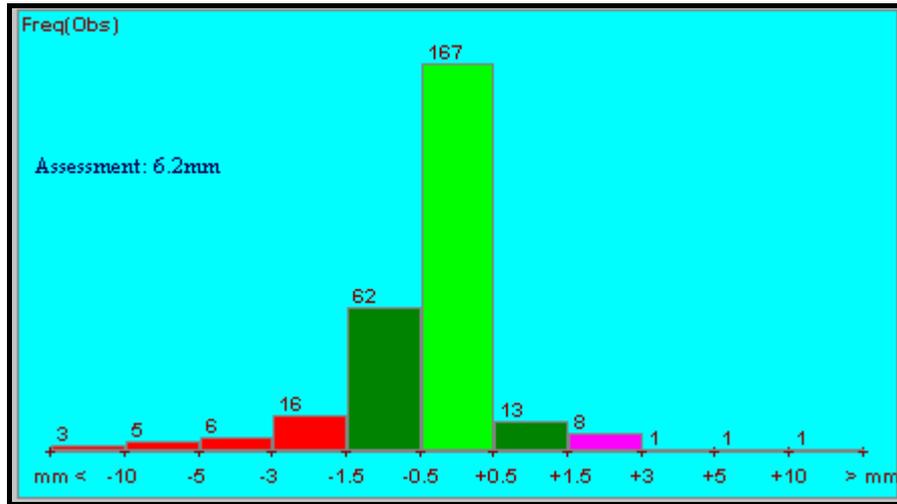
Residuals

fig 1.1a

The residuals are corrections to observed height differences in each level run. Ideally, such corrections should be insignificant, zero. The centre of information therefore, are the observed height differences and the histogram displays residual corrections as deviations. The Assessment is ±6.21mm. Therefore the margin of correction is within ±6.21mm for 99% of the distribution, and is a measure of quality to compare with job specifications.
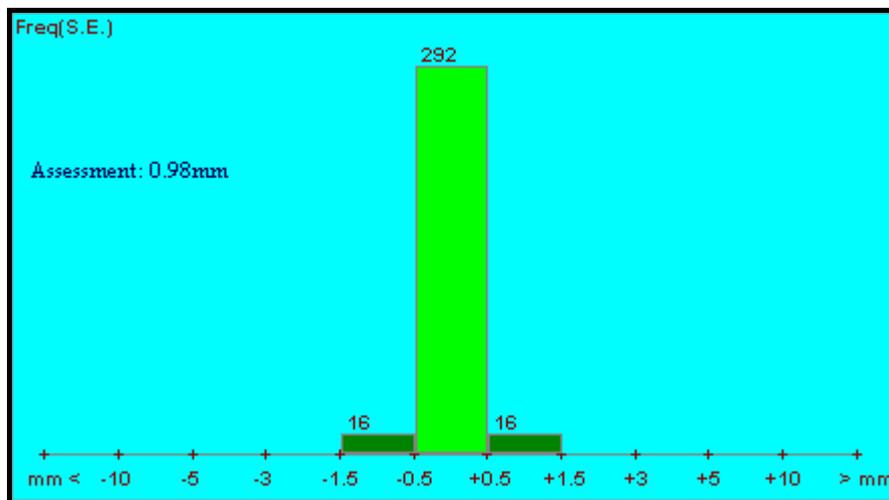
Precisions

fig 1.1b

Similarly, the precision of adjusted heights should be very high, ideally zero. The histogram and distribution illustrate the deviations from this central position. The Assessment, ±0.98mm again provides criteria for an overall judgement.

Deformation Analysis

Deformation monitoring usually involves a selected number of points suitably located in the area of interest. In the ideal circumstances, there should be as many points as possible, but for time and cost implications. However, if the points are considered as a sample of population, then any judgements based on this principle will be closer to the ideal circumstances and therefore provide a safer basis for assessing deformation.

SMS offers height as well as 3-D monitoring. In each of these cases, the centre of information is either the base visit or the last epoch, and therefore any movements relative to current visit. The histogram, fig 1.2, illustrates movements as deviations from the base or last visit. Assuming a normal distribution, the Assement provides a margin of movement for 99% of the population. Conversely, there is a 99% probability that any deformation is within the stated tolerance of ±2.89mm. This parameter is an important indicator and should be watched at each visit as a basis of overall judgement.
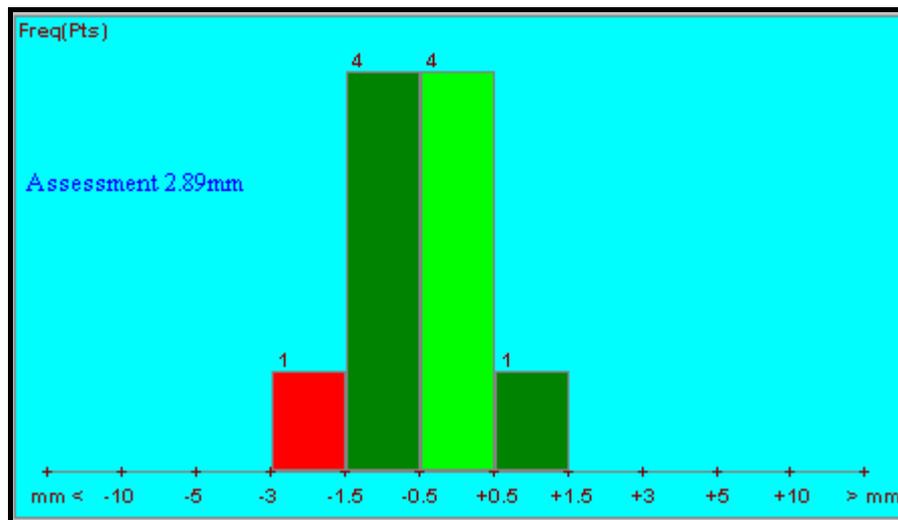

fig 1.2

Summary

The introduction of statistical parameter, Assessment, provides additional criteria in evaluating the quality of survey projects. It is particularly useful at managerial level, in huge projects that involve mass of survey information.

The application in monitoring is even more useful. It is another step forward in management that enables software to decide if and when, or where there is deformation.

Conclusion

The discussions in this chapter provide adequate introduction to Survey Management System. Against this background the actual use of the program can begin. The next chapter, Getting Started discusses the practicalities of running the program with emphasis on program structure and hardware.