of data corresponds to one station or one measurement. Required input for a given line of data must be in a prescribed order. All lines of data are finished with a "0" (zero) or "1" (one). A zero indicates the following line includes data in the same subset. A one indicates the next line includes data which belongs to the next subgroup of data. The last line of input in subgroup five should end with a one, indicating the end of the data file. The zero or one is called a flag, and is always an integer.

Stations can have alphanumeric names up to 16 characters in length. A station name should not have blank spaces in it. All angle and azimuth degrees and minutes should be in integer form, while the seconds can be a real or integer (reals contain decimal points, integers do not). All distances and coordinates should be input as real numbers.

GENER sets up the data file properly for you. Use it and you can ignore all the discussion of data file structure.

> All angles are assumed to be measured clockwise, i.e interior angles right. All azimuths (solars, etc.) are assumed to be measured clockwise from north (north azimuth).
>
> If using state plane coordinates astronomic or geodetic azimuths can be converted to grid azimuths using a program option. All input azimuths must be of one type either all geodetic or all grid.

Coordinates should **not be negative** and should be less than 10,000,000.00 to meet output format restrictions.

If you have negative control coordinates, GENER will be very mad at you.

LSA File Format:

```
DATA FILE SUBGROUP #1 - CONTROL COORDINATES

     All lines in this group have the following form:
     station        X coordinate     Y coordinate    flag
     (character)    (real)           (real)          (integer)

DATA FILE SUBGROUP #2 - Distance measurements

     All lines in this subgroup have the following form:
     Occupied       Sighted
     Station        Station          Distance         flag
     (character)    (character)      (real)           (integer)

DATE FILE SUBGROUP #3 - ANGLE MEASUREMENTS (Assumed clockwise)

     All lines in this subgroup have the following form:
     Backsight    Occupied   Foresight
     Station      Station    Station   Degrees Minutes Seconds flag
     (char)       (char)     (char)    (int)   (int)   (real)  (int)

DATA FILE SUBGROUP #4 - AZIMUTH MEASUREMENTS (assumed from north)

     All lines in this subgroup have the following form:
     Occupied     Sighted
     Station      Station  Degrees   Minutes  Seconds  flag
     (char)       (char)   (int)     (int)    (real)   (int)
```

DATA FILE SUBGROUP #5 - UNKNOWN STATION APPROXIMATE COORDINATES

All lines in this subgroup have the same format as in subgroup #1.
If there are no measurements of one type (like azimuths) insert zeroes for a line of a subgroup with a flag of one. For azimuths this would look like: 0 0 0 0 0. 1

All estimates of standard errors of observations are generated internally by the program from user input and are thus left out of the data file. The user is given the option of changing the default standard errors, or can input individual standard errors for each observation using computer program **SD**.

The following error estimates are being generated by default:

* Distance error estimate = 0.03 ft. + (3/1,000,000)* distance;

  (the error estimates will be in meters if distances and coordinates are in meters)

* Angle error estimate = 6 seconds;

* Azimuth error estimate = 0.1 seconds;

* X or Y control coordinate error estimate = 0.001 ft.

***Note:** The actual default values are different than specified here, and depend on whether the job definition file was created with CMM-MANAGE or the stand alone program PROJEC.*

The small azimuth default standard error is used because an azimuth is often used to orient a network with only one control station, thus that standard error essentially "holds" that line at that orientation. If control coordinate standard errors are left at their default values it is highly unlikely that any adjustment of their input positions will occur. It is important to get used to the fact that control coordinates contain error, too, so in networks where more than one control station exists (as an example, a township with GPS stations at certain points with redundant traverse in between), it may be justifiable to assign standard errors to the control coordinates which will enable their adjustment along with the rest of the unknown station coordinates.

Before the actual least squares solution begins, a reordering of stations occurs which minimizes the bandwidth of the normal equations so the solution will occur much faster. The iterative solution for the bandwidth will appear on the screen. Larger networks will generally have larger bandwidths, as will networks of high redundancy. Lots of sideshots and open ended traverses make the bandwidth increase dramatically, and thus the solution slows way down. Try to add sideshots and open ended traverse to the network using computer program **SSHOT**.

The solution begins after the minimum bandwidth is found, and each iteration of updates to coordinates will appear on the screen (quickly for small networks, slowly for large networks). A rough estimate of time for an iteration on a 20 mHz PC-AT is 30 seconds for 100 stations, 10 minutes for 500 stations, 30 minutes for 1000 stations, and 1.5 hours for 2000 stations. These times are dependent on the bandwidth of the network, and are based on some "typical" actual survey networks.

The standard error of unit weight for the iteration will appear. This number should go down as iterations occur. If it does not you have blunders in your data. A final standard error of unit weight of close to one (between 0.7 and 2) indicates you did a good job of estimating the random errors in your observations. A final standard error of unit weight of much greater than 2.5 should be considered suspect. If this occurs and you are certain of the estimation of your observation standard errors, and you are certain there are no blunders in your measurements, it usually indicates problems with the control stations in your network. Try changing some of the control points to unknowns, or assign their coordinates larger error estimates, and see if you can isolate the problem.

The number of iterations will usually never exceed 3 since the approximations for unknown coordinates computed by **GENER** are generally fairly reliable. Iteration will quit for one of the following reasons:

(1) The largest coordinate update is less than 0.005 ground units.

(2) The standard error of unit weight is not improving.

(3) 4 iterations have occurred and (1) and (2) are not yet satisfied.

A large increase in the standard error of unit weight usually indicates a blunder is in the data. A very small increase in the standard error of unit weight means the solution has stabilized and iteration should cease since the solution will probably not improve.

After iteration is terminated, error analysis is performed if the user has selected this option. Error analysis means standard errors for all coordinates and error ellipse information for all stations will be computed. In large networks there is a significant amount of computations required for this process, so if the error information is not required you will usually not select this option. If later you needed that information, all you would have to do is run the program again with the error analysis option selected. Very large networks which require temporary storage of the least squares equation coefficients is a file on your hard disk. This file is erased from your hard disk when program execution terminates. In cases where this temporary storage is required (usually 400+ stations) error analysis will not be allowed by the program due to the extensive execution time that would be required for it to complete.

Residuals are now calculated for all observations and written to the **.ADJ** file. Only residuals above user-selected limits are output (inputting a zero means all residuals of that observation type will be output). Remember control coordinates may adjust so they can also have residuals calculated for them. Root-mean-square (RMS) values for all observation types are calculated and the largest residual for each observation type is highlighted. The coordinate output, error analysis, and residual information is not written to the screen (only to the **.ADJ** file) because it moves by your eyes too fast to be interpreted.

LSAQ runs completely without prompts unless the re-weight prompt is selected in project definition. Weights are inversely proportional to standard errors. Re-weighting invokes a tool called robustness which is very useful in blunder detection. In robustness a new standard error is calculated by averaging its original standard error with the absolute value of its post-adjustment residual. This creates a filtering process where observations with low residuals will get lower standard errors, and those with larger residuals will get larger standard errors. This process can often result in the blunder (or potential blunders) having unusually large residuals in the post-adjustment statistics, thereby isolating the problem.

It is really amazing how successfully this operation can be in blunder isolation even when the network has little redundancy. One should try this tool by inducing a blunder in a network on purpose, and seeing if it will find it. The software gives you the option of re-weighting any type or combination of observations. If the re-weighting algorithm is invoked the software will return to the actual adjustment phase of the software.

If selected in the project definition, the software will next compute adjusted bearings and distances.

The last defined option from project definition of **LSAQ** is the creation of the**.COR** file, which is an ASCII listing of station ID, adjusted X, adjusted Y, point scale factor (no elevation factor), and convergence angle (the last two items are not output if a state plane zone was not selected). If a state plane zone was selected, the **.GEO** is also created which is a list of adjusted latitudes and longitudes. The output file (.ADJ) can now be viewed on the screen or printed.

The creation of the **.COR** file is essential for use of computer program **CHECKER** as it uses the coordinates in this file.

LSAQ is set up to adjust maximums of 3000 stations, 4000 distances, 4000 angles, and 3500 azimuths on an PC-AT with 550 k of available RAM. Bigger networks can be adjusted if a user asks for a larger version (there is a trade-off between larger versions and efficiency of the system).

LSSM

LSAQ is a high performance Least Squares Analysis Program for a PC, and as such it requires approximately 547K of free ram. In many cases such large network solutions are not necessary and sufficient RAM is not available. In that case, a smaller memory model is provided and named LSSM. It can be 'installed' in the system by running the batch file LTLLSAQ. This copies LSSM.EXE to LSAQ.EXE. The batch file BIGLSAQ is provided to restore the original LSAQ.

MANAGE.EXE

MANAGE is the executable portion of a partnership CMM-**MANAGE** that are responsible for the main menu. CMM is a batch file that actually runs each selection after **MANAGE** has exited. The system was designed in this bizarre fashion to make the maximum amount of RAM available to **LSAQ**. With this system **MANAGE** is no longer in memory when the selected programs run. **MANAGE** does contain the project definition screens. You cannot run **MANAGE** as a stand alone program and have it work, it must be called through CMM.BAT.

CMM is used to maintain default parameters for your survey network projects. It also allows you to select appropriate programs, edit files (which also allows one to view files), and change projects.

CMM allows you to directly run **GENER** (approximate coordinate generation), **LSAQ** (adjust network), **CHECKER** (post-adjustment closures), and **DXFLSA** (creation of **.DXF** file of traverse data).

> All of the Cadastral PLSS computation utilities are accessed by selecting the Utilities option.

The G and A options on the Main Menu

Selection of the G (Adjust) option in **CMM** leads you to define 19 parameters for a least squares adjustment of a survey. *Options 1 - 5* pertain to state plane information. If no state plane zone is selected these first five options are ignored. Any state plane zone can be selected in option 1. In option two the user can select NAD 27 or NAD 83. Option 3 has no meaning in NAD 27 as the U.S. Survey Foot is assumed. In NAD 83 the user can select units of meters, U.S. Survey Foot, or U.S. International Foot. All distances and control coordinates must be in the same units.

Option 5 is a project elevation for reduction of distances to a sea level datum. If the terrain is very undulating, the user may want to input a series of elevations into LEV.LSA (option 5, see **LSAQ** user's manual) for a better estimate of elevations at stations. If option 4 is selected (Yes input) one should still input a reasonable project elevation as that quantity is used in elevation reductions in computer program **GENER** and as a default for all utility programs.

Option 6 tells the adjustment programs if the azimuths are geodetic, (Yes) and thus need to be reduced to their state plane grid equivalents, or if the azimuths are already reduced to grid (No).

If a user desires to read individual error estimates from a file a 'Yes' is answered to the standard error question. You must have run **SD** prior to create this file. If a 'No' is answered to the standard error question the user is allowed to edit default error estimates for distances, angles, azimuths, and control coordinates. Control coordinates error estimates should remain at 0.001 unless it is really desired that control coordinates be allowed to adjust.

The next page of **LSAQ** options involve if error analysis (standard errors and ellipse information) is to occur. In large networks a 'Yes' input will be overridden due to the inordinate time required to perform these computations.

The next inputs define limits for residual printout. If the absolute value of a residual is less than the limit it will not be printed. A limit of zero will result in all residuals of that observation type to be printed.

The next option is selected if one desires to print adjusted distances and bearings in the **LSAQ** output file.

The next-to-last option is selected if an ASCII list of adjusted coordinates is desired. This option must be selected if one desires to use computer program **CHECKER** or the Utility programs as it passes adjusted coordinates to these routines.

The final option is selected if one desires to use re-weighting in **LSAQ** in blunder detection. If this option is not selected **LSAQ** runs in a batch mode.

CMM allows one to modify all options, update a project definition file, and select a new project. When a new project is selected the program uses a definition file of that name. If the definition file for the new project does not exist (a new job) the previous project's defaults are used as initial defaults.

PROJEC.EXE

PROJEC is a direct way to create, modify or rename a project .DEF file. It has largely been replaced by data entry thru CMM, but is still useful on occasion as a way to enter trial large error estimates as part of a blunder hunting exercise. CMM limits error estimate entry to reasonable ranges, PROJEC does not. One unusual aspect of PROJECT is that you define the projects parameters, working from the current project as defaults, then change the project name on EXIT from the program.

PROPORT.EXE

PROPORT is a corner by corner single and double proportioning program. It makes significant use of the **.REC** files as created with **INREC**.

```
PROPORT - Proportionate corner re-establishment program. v1.00  bp

                    Project Name:   GR1044

No. of Corners (used/unused): 392/3608     No. of Record Dimensions:   168

            Corner to be proportioned:

              NORTH          SOUTH          EAST          WEST
         ---------------  -------------  -------------  -------------
Control:
Σ LAT's:
Σ DEP's:

F1 Help   F2 Save   F3 Exit   F4 Report   F10 Time
```