Chapter 8

Options *(updated September 06, 2009)*

Setting Up the Working Environment

The purpose of the OPTIONS module is to set up the run-time parameters for COLUMBUS. These parameters may include datums, projection zones, units, among others; in other words, the basic information that COLUMBUS will need to know for data entry, computation and reporting.

The OPTIONS module enables you to view and modify the current options and save them for future use. Many of the options will be selected once for use by all projects. Each time an OPTIONS dialog box is opened, changes to its contents can be made. If you are satisfied with the changes, select the **OK** button. The changes will become active for the current project, any new projects created and future sessions with COLUMBUS. To close a dialog box without changing its settings, click the **CANCEL** button.

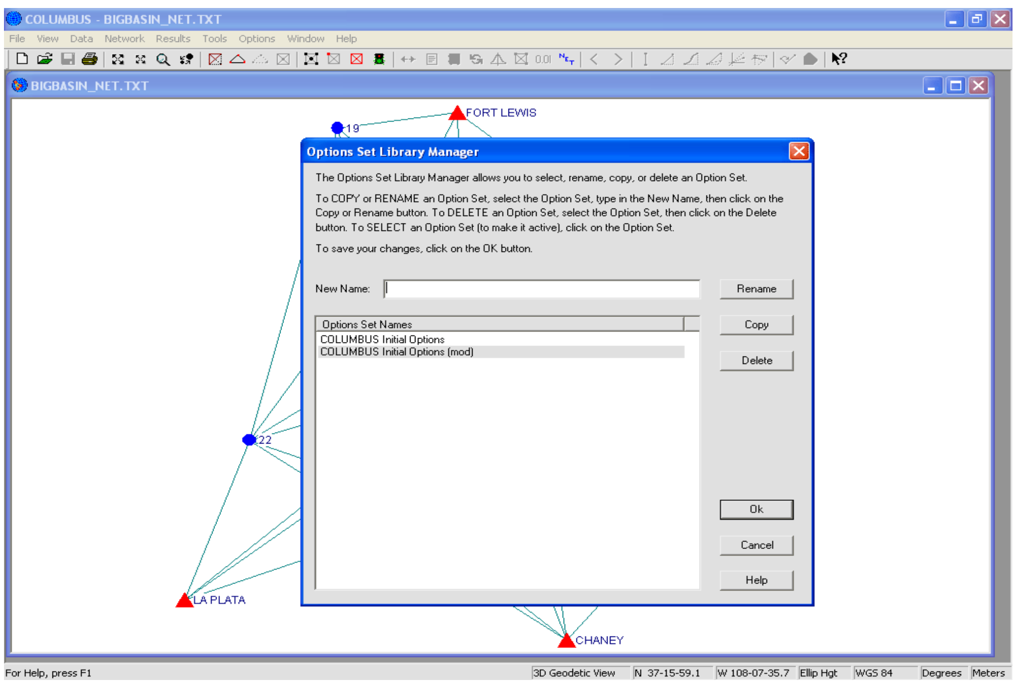
Options Library Manager

The Options Library Manager allows you to manage different Options Sets. Any Options Set can be activated for the current project.

Multiple Options Sets allow you to customize your COLUMBUS Options based on the type of project you are executing in the field. Some projects might require less precise measurements, therefore, you might want different default observation standard deviations for these projects. Other projects might occur in different State Plane zones or might require a different linear unit setting.

By establishing an Options Set for each project type, you can easily activate a specific Options Set prior to computation (i.e., you don't need to remember all the settings you used previously for the same project type). You simply activate the Options Set that is suitable for the type of project you are working with in COLUMBUS.

Each Options Set, has a unique name (established by you) for easy remembering.



Usage

COLUMBUS is shipped with an initial Options Set called **COLUMBUS Initial Options**. This initial set of Options Settings can be copied (then modifed) as needed. It cannot be altered or deleted (it's read only).

Only one Options Set can be active at a time. Open the OPTIONS - LIBRARY MANAGER to see the active Options Set.

When the OPTIONS - LIBRARY MANAGER dialog is opened, there are instructions for **renaming**, **copying**, **deleting**, and **activating** an Options Set.

Whenever you change a specific Options Setting (e.g., linear units, state plane zone, active datum, network adjustment type, default azimuth standard deviation, etc.), the current active Options Set will be copied (if not in a modified state) internally and labeled as modified **(mod)**. This new Options Set will become the active Options Set. Subsequent changes will be placed in this modified Options Set.

To **Freeze** an Options Set from additional changes, remove the **(mod)** text by changing its name.

Example

You currently have the Options Set called **Wild T2** active. You then change the zenith angle default standard deviation from 10.0 seconds to 5.0 seconds. COLUMBUS will automatically create a new (or switch to the existing) Options Set called **Wild T2 (mod)** and set it as the active Options Set. The new standard deviation change will have been placed in the **Wild T2 (mod)** Options Set.

A few minutes later, you then decide to change the linear units to U.S. Feet (from meters). That change will also go into the active **Wild T2 (mod)** Options Set. To ensure no more changes are made (e.g., accidentally) to this Options Set, rename it to something else by removing the **(mod)** text. To rename it back to the original **Wild T2** name, you must first delete the existing **Wild T2** Options Set.

Two ways to change an Options Set

An existing Options Set can change from a non modified state (no **(mod)** text at the end) to a modified state by:

1. Entering any of the Options dialogs, then clicking on the OK button.

2. Opening (File - Open or File - Append) a file which contains Options Settings or in some way alters an Options setting value while the file is loaded. One subtle change might include loading a file that has the linear units set to U.S. Feet, when the current linear units are set to meters. Another subtle example is when you load a file with a different datum setting than what is currently active in COLUMBUS.

In either case, the current Options Set will be copied and changed to a modified state (or switched to if the modified Options Set already exists), then made active. If the Options Set was already in the modified state, the changes will be put into that Options Set directly and it will continue to be the Active Options Set.

Saving your changes

After making a series of changes in the OPTIONS - LIBRARY MANAGER dialog (e.g., renaming, deleting, or copying), you can cancel these changes by simply clicking on the Cancel button.

Click the OK button to save your changes.

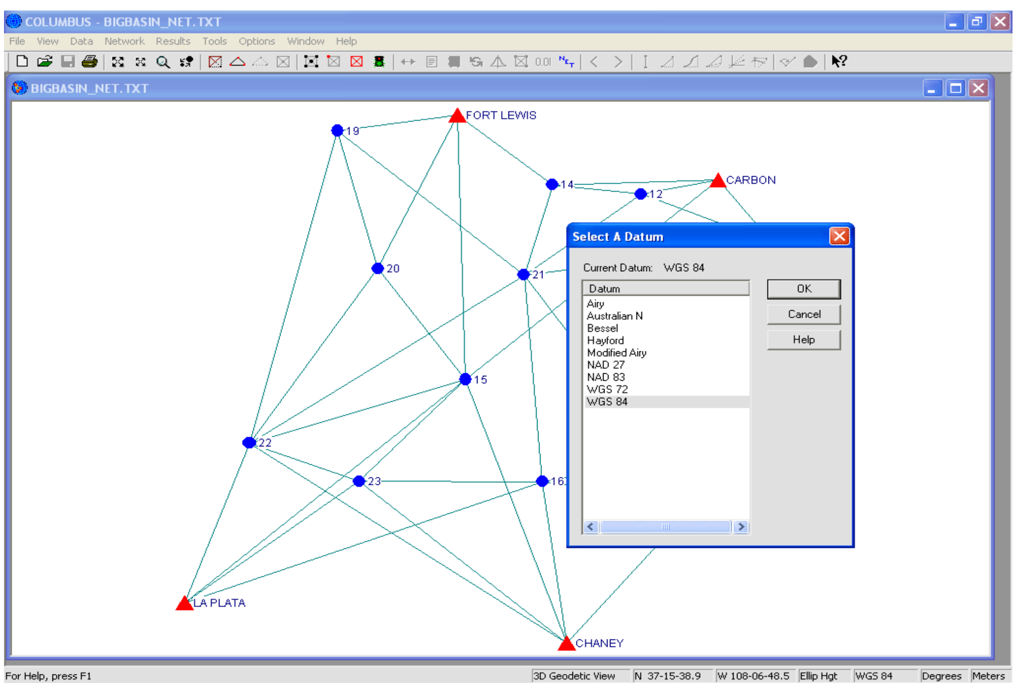
Datums

The Datums dialog allows you to establish the active datum for COLUMBUS operation. All data (stations and observations) are logically linked with a datum.

To perform a network adjustment based on the WGS 84 datum, your field data must be associated (linked) to the WGS 84 datum, and the WGS 84 datum must be active. To link data with a datum, select the desired datum for the project area prior to entering new data through the input dialog grids. If you plan to open your data from an ASCII (Text) file, either define the correct datum at the top of the file or make the datum active prior to opening your ASCII (Text) file. For more information on the format of the ASCII (Text) file, please see APPENDIX A.

If you discover that you have linked your data to the wrong datum (e.g., NAD 27, when you wanted NAD 83), simply enter the TOOLS - DATUM SWITCH dialog and **Pick** NAD 27 as the Old Datum and NAD 83 as the New datum. Click **OK** to make the change. Then, set NAD 83 to be the active datum by entering this dialog and selecting NAD 83.

Another way to change the datum/data linkage is to save your current data to a COLUMBUS ASCII (Text) file, then manually change the datum parameters within that file. Then, simply reload the file into COLUMBUS.



The datum is the mathematical ellipsoid representing the Earth's surface. The various datums (used throughout the world) are the result of periodic improvements due to technological advancements in the science of geodesy. Some datums are global in nature, meaning they were designed to describe the entire Earth's surface relatively well (for example, WGS 72, WGS 84, etc.). Other datums are locally applicable, meaning they were designed to fit a portion of the Earth's surface relatively well. For example, NAD 83 was designed for use in North America.

COLUMBUS has the capability to use any datum. Some of the pre-set datums shipped with COLUMBUS are shown below. To add datums to this list, see the DATA - DATUMS section in the DATA chapter of this manual.

	a	1/f
Airy	6,377,563.396	299.32496
Australian	6,378,160.0	298.25
Bessel	6,377,397.155	299.1528128
Hayford	6,378,388.0	297
Modified Airy	6,377,340.189	299.325
NAD 27	6,378,206.4 m	294.9786982
NAD 83	6,378,137.0 m	298.257222101
WGS 72	6,378,135.0 m	298.26
WGS 84	6,378,137.0 m	298.257223563

The column denoted by the letter “a” represents the semi-major axis of the reference ellipsoid. The “1/f” column represents the

$$\frac{1}{flattening}$$

ratio of the ellipsoid.

Note: When data (stations and observations) within the project are saved to a COLUMBUS ASCII (Text) file, the datum name, semi-major axis, and flattening ratio are also written to the file. When this file is opened during a future session, the **first** datum definition ($DATUM keyword) read from the file will become active for the COLUMBUS session.

Projection Zones

The Projection Zones command allows you to setup a State Plane, UTM or Custom Projection. Many State Plane zones are internally supported by COLUMBUS. For International users, the term State Plane refers to the specific projection zone in the United States. Internally supported International State Plane zones can be found at the bottom of the State Plane zones list within the State Plane zones dialog box.

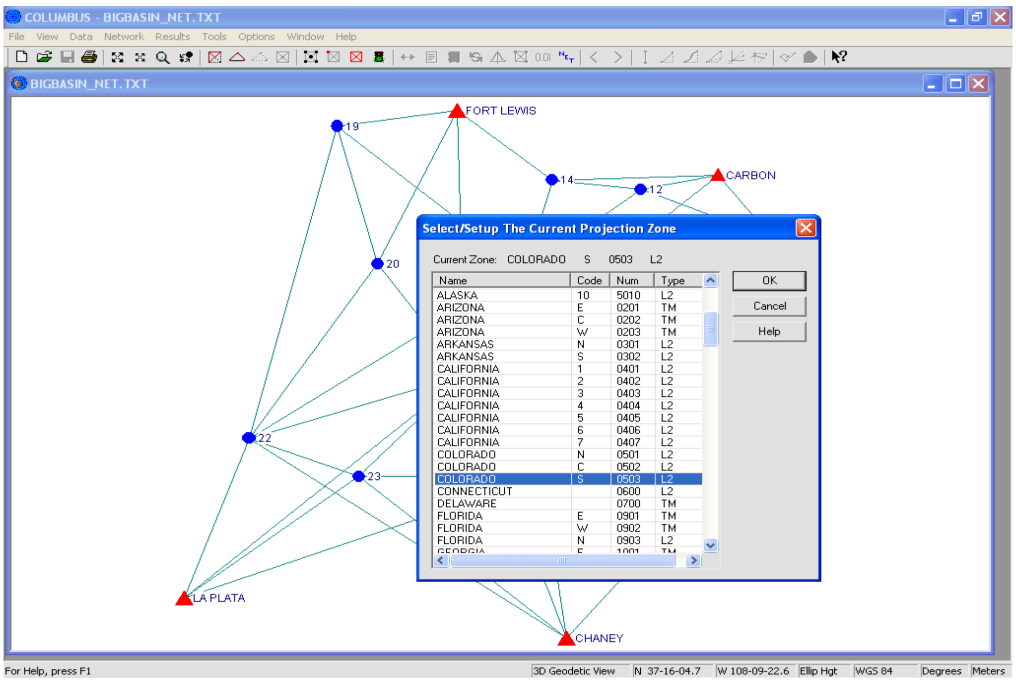
Custom projections include: Lambert Single Parallel, Lambert Double Parallel, Transverse Mercator or Azimuthal Equidistant.

To select/set up a State Plane zone or Custom projection, select the State Plane Zone menu option. To set up a UTM zone or any Transverse Mercator zone with origin at the equator, select the UTM Zone menu option.

State Plane Zones

COLUMBUS includes several pre-packaged State Plane projection zones. These include many North American zones and some International zones. Supported zones are presented alphabetically beginning with the North American zones, followed by the International zones.

Each zone in the table is followed by a two letter identifier that indicates the projection type. Transverse Mercator zones are identified by “TM.” Lambert zones are represented by the letters “L1” or “L2.” L1 identifies Lambert projections based on the Single Parallel method. L2 identifies Lambert projections based on the Double Parallel method. The Azimuthal Equidistant zone type is represented by the letters “AE.”

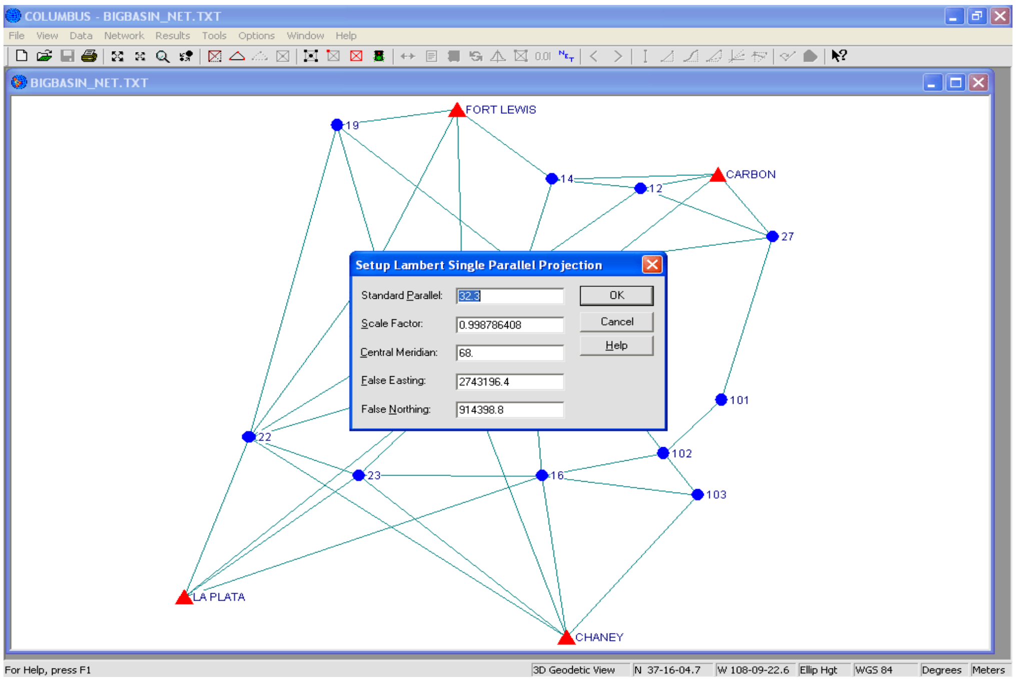


To select a zone, click on the zone name (to highlight it), then click on the **OK** button. All State Plane computations are based on the active datum, including the special case for the NAD 27 State Plane system.

To set up a Custom projection, select one of the first four zones in the list. For example, to set up your own zone constants for a Transverse Mercator projection, highlight the **UD Transverse Mercat TM** text and click on the **OK** button. COLUMBUS will present a dialog to enter the user-defined zone parameters. Enter your parameters, then click **OK**. The Custom projection becomes the active projection.

User-Defined Lambert Single Parallel

This user-defined projection type is based on the Lambert Single Parallel projection method. The five parameters required to define this projection method are displayed below:

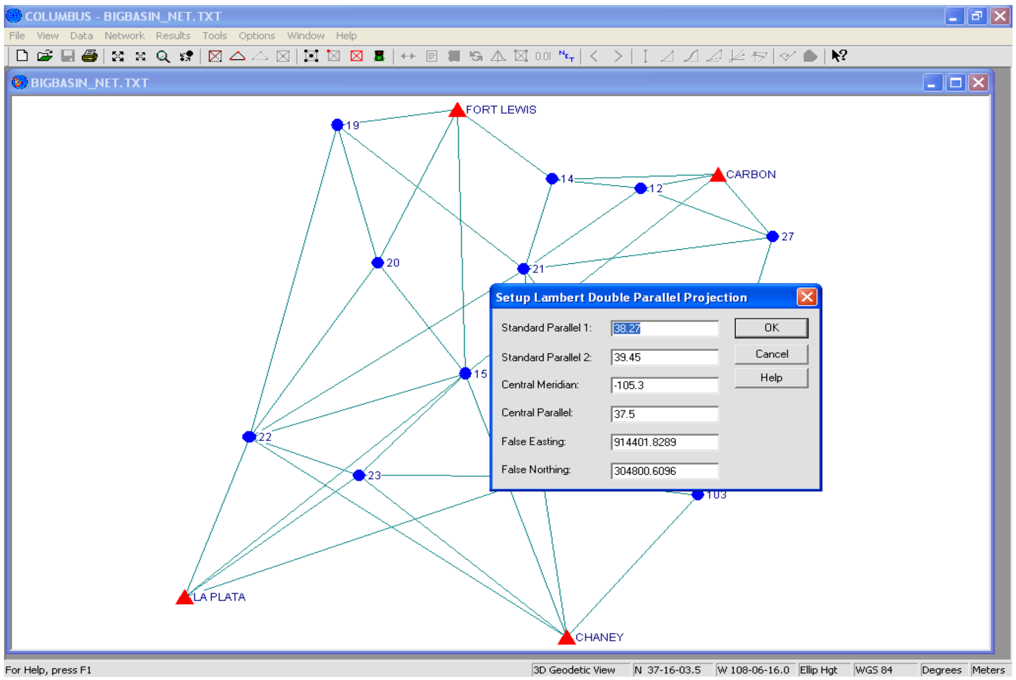


- The Standard Parallel must be entered in DD.MMSSsssss format (positive north, negative south).
- The scale factor is a unitless quantity.
- The Central Meridian should be entered in DD.MMSSsssss format (positive east, negative west).
- The False Easting must be entered in the active linear units.
- The False Northing must be entered in the active linear units.

Enter the projection-specific parameters and click on the **OK** button. This zone will then become the active (current) projection zone.

User-Defined Lambert Double Parallel

This user-defined projection type is based on the Lambert Double Parallel projection method. The six parameters required to define this projection method are displayed below:

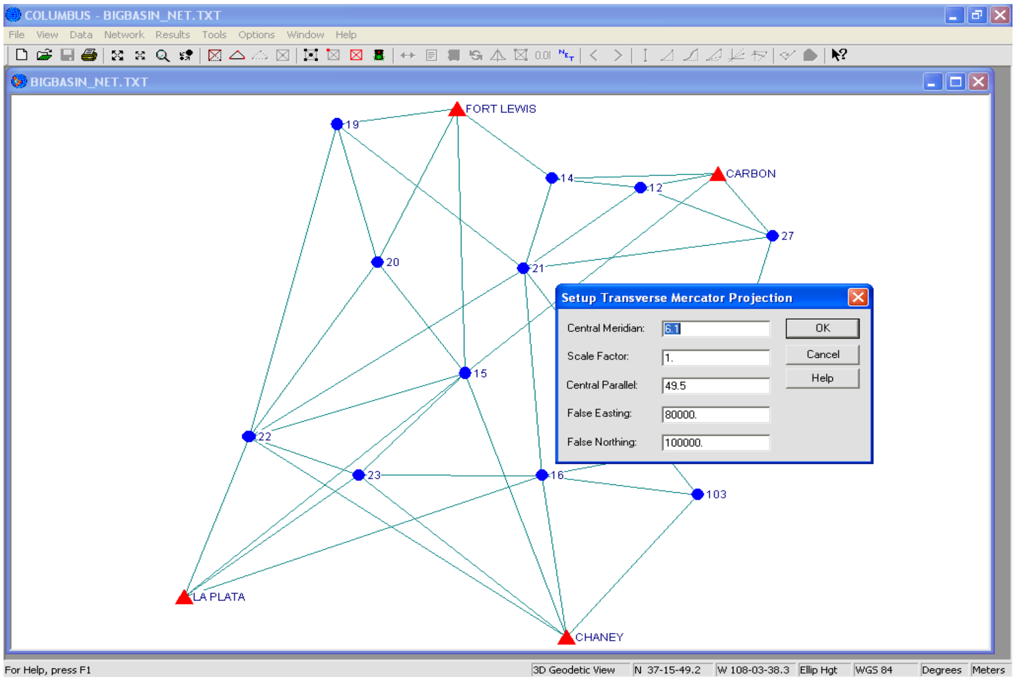


- The Standard Parallel 1 must be entered in DD.MMSSsssss format (positive north, negative south).
- The Standard Parallel 2 must be entered in DD.MMSSsssss format (positive north, negative south).
- The Central Meridian must be entered in DD.MMSSsssss format (positive east, negative west).
- The Central Parallel should be entered in DD.MMSSsssss format (positive north, negative south).
- The False Easting must be entered in the active linear units.
- The False Northing must be entered in the active linear units.

Enter the projection-specific parameters and click on the **OK** button. This zone will then become the active (current) projection zone.

User-Defined Transverse Mercator

This user-defined projection type is based on the Transverse Mercator projection method. The five parameters required to define this projection method are displayed below:

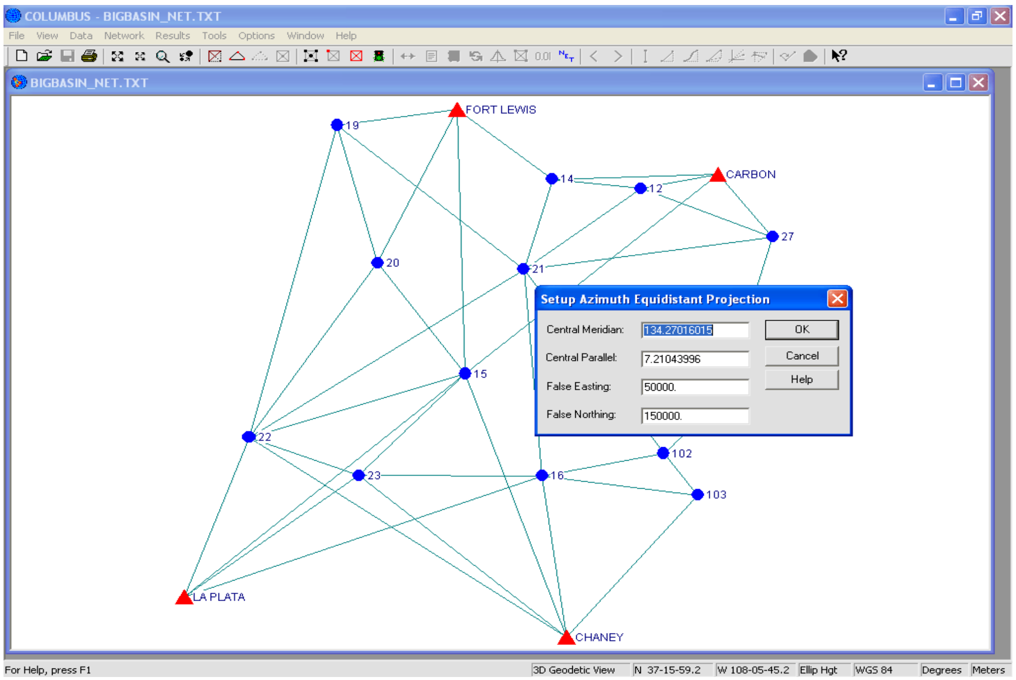


- The Central Meridian must be entered in DD.MMSSssss format (positive east, negative west).
- The scale factor is a unitless quantity.
- The Central Parallel should be entered in DD.MMSSssss format (positive north, negative south).
- The False Easting must be entered in the active linear units.
- The False Northing must be entered in the active linear units.

Enter your data, then click on the **OK** button. This zone will then become the active (current) projection zone.

User-Defined Azimuthal Equidistant

This user-defined projection type is based on the Azimuthal Equidistant projection method. The four parameters required to define this projection method are displayed below:

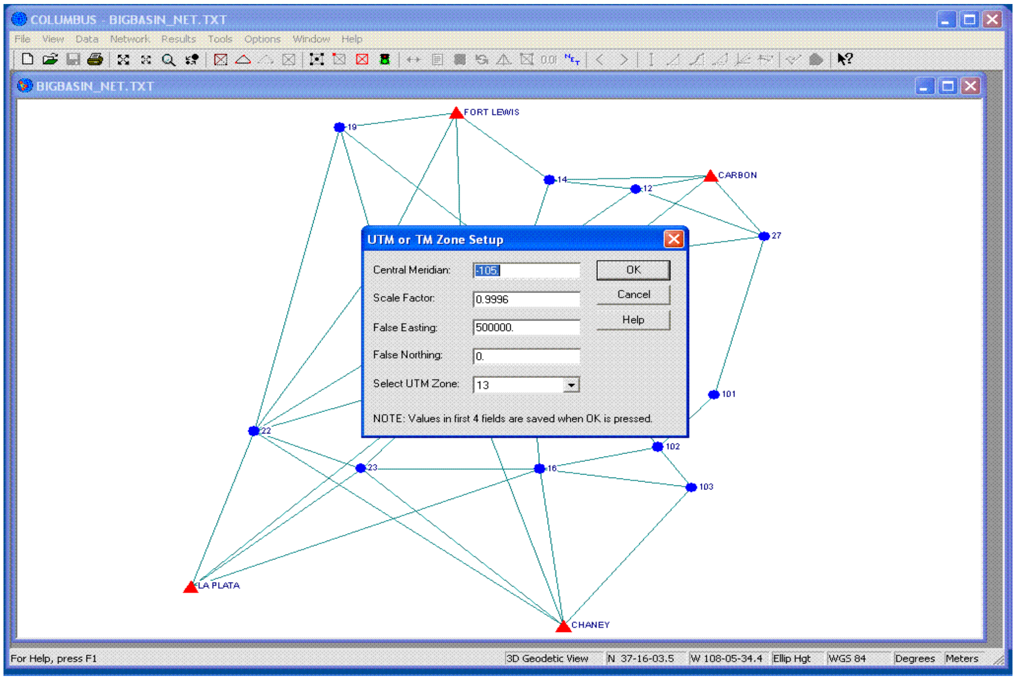


- The Central Meridian must be entered in DD.MMSSsssss format (positive east, negative west).
- The Central Parallel should be entered in DD.MMSSsssss format (positive north, negative south).
- The False Easting must be entered in the active linear units.
- The False Northing must be entered in the active linear units.

Enter the projection-specific parameters and click on the **OK** button. This zone will then become the active (current) projection zone.

UTM Zone Setup

This dialog box allows you to set up the UTM (Universal Transverse Mercator) zone for your project area. You can actually set up any Transverse Mercator zone (TM, 3TM, etc.), provided the Central Parallel is the equator (i.e., latitude of zero). Other Universal Transverse Mercator type zones, which have a central parallel other than at the equator, can be set up by selecting the **UD Transverse Mercator** list item in the State Plane Zone dialog (described previously).



There are 60 UTM zones encircling the globe. They are arranged six degrees apart, with the central meridian located at the midpoint meridian of each zone. For the Eastern Hemisphere, the central meridians start at 3 degrees and continue to 9 degrees, 15 degrees, 21 degrees, etc. The Western Hemisphere is similar, but the central meridians are negative (i.e., -3 degrees, -9 degrees, etc.).

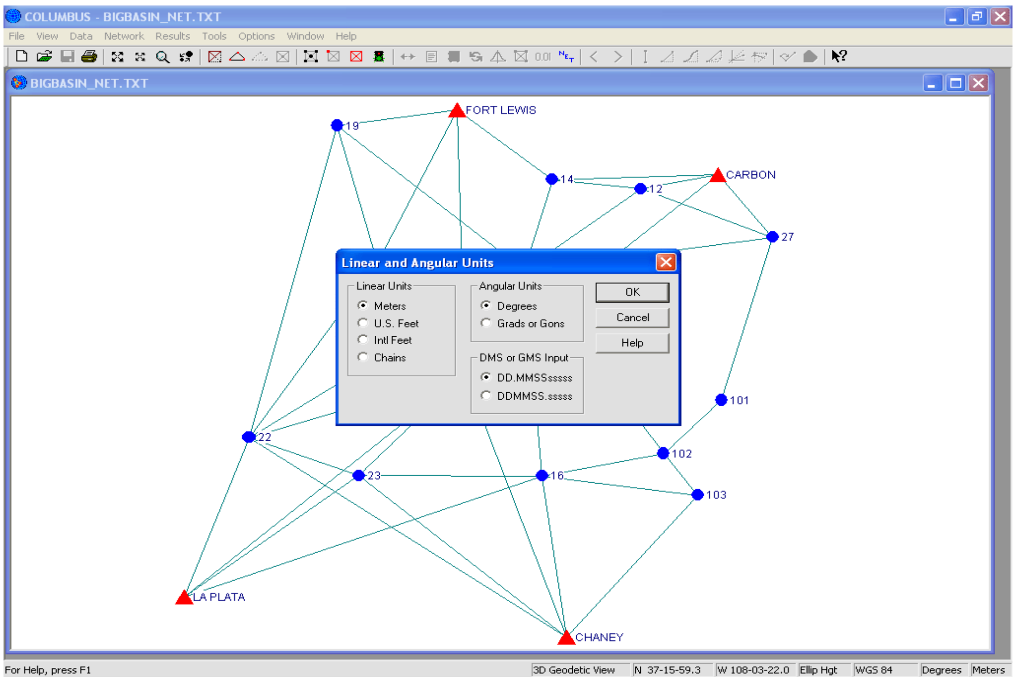
- The Central Meridian must be entered in DD.MMSSssss format (positive east, negative west).
- The scale factor is a unitless quantity.
- The False Easting is the east-west coordinate assigned to the Central Meridian.
- The False Northing is the north-south coordinate assigned to the equator. It is usually zero for the Northern Hemisphere and 10,000,000 meters for the Southern Hemisphere.

You can also quickly set the UTM zone by selecting the commonly used zone number (1 - 60). Select the **User Defined** list item when entering custom zone parameters.

Enter or make your selections, then click on the **OK** button. This zone will then become the active (current) projection zone.

Units

This dialog allows you select the linear and angular units for input and output. Once the units have been chosen, all applicable linear and angular input must be entered in these units. For ASCII (Text) files, you may declare the unit type for its data elements within the file itself. If you do not define the units within the file ($UNITS keyword), COLUMBUS assumes they are represented in the active COLUMBUS units when the file is opened.



Linear Units

Linear unit options are:

1.0 Meter	=	3.2808333333	U.S. Survey Feet
1.0 Meter	=	3.2808398950	International Feet
1.0 Meter	=	0.0497095959	Chains
1.0 U.S. Survey foot	=	0.3048006096	Meter
1.0 International Foot	=	0.3048000000	Meter
1.0 Chains	=	20.1168402337	Meter (66 U.S. Survey Feet)

Internally, COLUMBUS keeps track of all linear quantities in meters. When reports are generated, COLUMBUS converts meters to the active linear units.

You can change the linear units at any time. For example, if you wish to enter all linear data in meters, but would like all output in U.S. Survey Feet, set the linear units to meters prior to data entry. After entering your data (all entered linear units must be in meters), change the linear units to U.S. Survey Feet and proceed to the applicable module to perform your computations.

Angular Units

The angular units option applies to the angular observation types (azimuths, directions, bearings, horizontal angles and zenith angles) and their standard deviations fields. All similar observation output is also reported in these units, including mapping angles for projected coordinates.

The angular units are not applicable to latitude and longitude data fields. These data types are always in DD.MMSSsssss units (or seconds of a degree for deflection of the vertical values - SS.sss).

360 degrees	=	400 gons
100 degree seconds	=	308.642 gons seconds

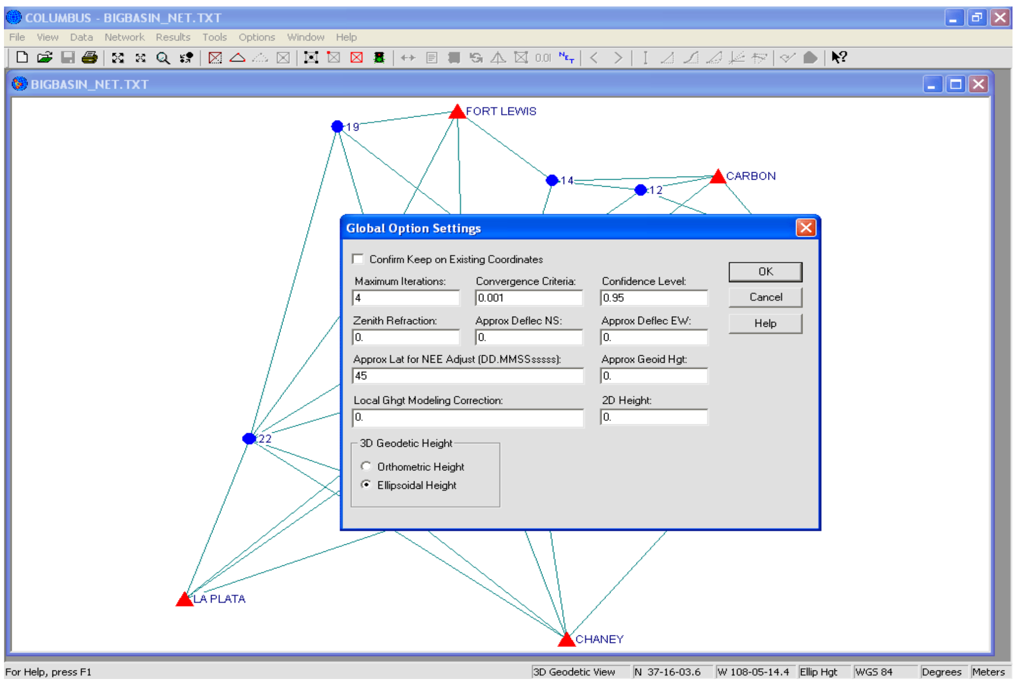
DMS or GMS Input Format

COLUMBUS currently supports two formats for angular entries: DD.MMSSsssss and DDMMSS.sssss, where D = degree, M = minutes, S = seconds. These formats only apply to on-screen data entry or ASCII (Text) file input. All reports and on-screen results are displayed in DD-MM-SS.sssss or GG-MM-SS.sssss format, where G = gons.

For example: An entry of 39° 02' 07.12345" should be entered in DD.MMSSsssss format as 39.020712345. The same entry in DDMMSS.sssss format is 390207.12345.

Global Settings

The Global Settings dialog facilitates entry of parameters applicable to many areas in COLUMBUS. Within this dialog, you can set whether to confirm Keeps on existing coordinates; the maximum number of iterations COLUMBUS will attempt when performing least squares computations; the least squares convergence criteria; the statistical confidence level; the zenith refraction correction; the approximate latitude to use when computing curvature/convergency corrections for local horizon north, east, elevation network adjustments and traverses; the optional approximate deflection of the vertical values for a project, approximate geoidal height, 2D Height and 3D geodetic Height.



Keep Option

Select this option if you wish to be prompted each time (when using the **KEEP** button) you update a coordinate position into COLUMBUS.

Maximum Iterations

With this option, you may select the maximum number of iterations to be performed during nonlinear least squares computations. COLUMBUS will terminate computations if the Convergence Criteria is met before the maximum number of iterations is reached. Otherwise, COLUMBUS will terminate when the Maximum Iteration value is reached.

Solution of least squares systems, as required by survey networks and the computation of datum transformation parameters, requires the simultaneous solution of numerous equations. Because the equations defining these mathematical models are non-linear (except 1D vertical networks, an iterative approach is required to converge on the optimal solution.

Non-linear models require an initial starting solution (in the case of geodetic networks, the approximate coordinates for each station serve as the initial starting solution) which is improved upon with each successive iteration. When the results from the current iteration are insignificant from the results of the previous iteration, the solution is said to have converged.

Occasionally, data are erroneously entered or they are inconsistent with the model. When this happens, the solution may not converge to an optimal result. Therefore, COLUMBUS offers you the opportunity to select the maximum number of iterations to perform in the event the model does not converge. This option works in conjunction with the Convergence Criteria. The first condition to be satisfied (Maximum Iteration or Convergence Criteria) will terminate computations.

For most computations, the iteration count usually is four (the default for COLUMBUS) or less. The closer the starting solution is to the best-fit solution, the faster the solution will converge. For geodetic network adjustments, COLUMBUS facilitates this reduced processing time by generating “close” approximate coordinates during network adjustment. These approximate coordinates computed by COLUMBUS are often within 0.10 meter of their adjusted positions.

Convergence Criteria

With this option, you may enter the acceptable convergence value for controlling the termination of non-linear least squares adjustment computations. COLUMBUS will terminate computations if the number of iterations performed exceeds the allowable number before the convergence criteria is reached. Otherwise, COLUMBUS will terminate when the convergence value has been obtained. The convergence constant must be entered in the active linear units.

As discussed previously, the solution of a system of non-linear equations requires an iterative approach. When the solution from the current iteration differs from the solution of the previous iteration by some insignificant amount (convergence), COLUMBUS terminates computations. Whether the difference is significant or not is determined by the Convergence Criteria value. The first condition to be satisfied (Maximum Iteration or Convergence Criteria) causes COLUMBUS to terminate least squares computations.

If the Convergence constant is set to 0.001 meter (1 millimeter), the model will converge when a change in each parameter (coordinate values for network adjustment) of the current solution differs from the previous solution by less than or equal to 0.001 meter.

Changing this number to a larger value may allow COLUMBUS to converge with fewer iterations, but the results may not reflect the precision of the field observations in the network. Alternatively, setting this number too small may result in a false sense of accuracy.

In general, the Convergence Criteria should be consistent with the accuracy of the field data collected. If your work approaches millimeter accuracy, then converging to 0.001 meter is realistic. If your field work is less precise, then increasing this number might be appropriate.

For a 3D geodetic network adjustment, the change on each iteration is expressed in terms of corrections to the latitude, longitude and height (orthometric or ellipsoidal) of each free (unknown) station. When the largest correction to all the free stations is less than the Convergence Criterion, the least squares adjustment is said to have converged.

Confidence Level

This option allows you to establish the global default confidence level for all network statistical analysis.

The confidence level is set by entering a numeric value, ranging from 0.01 (1%) to 0.99 (99%). For example, to set the confidence level to 95%, enter 0.95.

Confidence Interval is defined as the interval within which we have a specified degree of confidence (expressed as a percentage) that an actual value lies. For example, if we know the theoretical mean μ and standard deviation σ, the 95 percent confidence interval for a random measurement is (μ - 2σ, μ+ 2σ), i.e., from μ - 2σ to μ + 2σ. In other words, we would expect the actual random variable to fall within this computed region 95% of the time.

Confidence Region is defined as the region within which we have a specified degree of confidence (expressed as a percentage) that an actual value lies. For normally distributed random errors in two dimensions, a confidence region is bounded by an ellipse. Therefore, assuming these random errors, a confidence region indicating accuracy of horizontal control survey coordinates is bounded by an ellipse. Confidence regions for surveys with positions reported in three dimensions would be bounded by an ellipsoid.

In general, at the 95 percent confidence level, we can expect the true coordinate positions will fall within the region bounding the computed coordinate value and its confidence region (interval, ellipse or ellipsoid) 95 percent of the time. As the confidence level is lowered from 95 percent to 68 percent, for example, the confidence regions (intervals, ellipses, or ellipsoids) will be smaller, i.e., at the 68 percent confidence level, we expect the true position will fall within the computed value and this smaller confidence region. For this reason, COLUMBUS will report greater precision for the distance errors, 2D error ellipses and 3D error ellipsoids at the 68% confidence level vs. the 95% confidence level.

Zenith Refraction

This option lets you enter a zenith angle refraction factor. These corrections are applied to zenith angles as a result of atmospheric refraction. The entered value can range from 0.0 to 0.5, with a value of 0.13 being typical. The zenith angle refraction constant is used to compute the zenith Refraction Correction (RC) by the following formula:

$$RC = \frac{K \times D}{2 \times R}$$

Where:

K = zenith refraction constant (0.0 - 0.5)
D = chord (slope) distance between the AT and TO stations
R = radius of Earth + ellipsoidal height + instrument height at the occupied station

The corrected zenith angle is given by:

$$zenith\ (corrected) \ = \ zenith\ (uncorrected) \ + RC$$

The amount of correction applied to each zenith angle is a function of the length of the chord distance between the stations, the selected K value, and the radius of the Earth at the observed station. For a larger correction, increase K. For no correction, set K to zero.

Refraction corrections apply to zenith angles in 3D geodetic network adjustments and in the COGO module when performing 3D Auto Traverse calculations.

Given the following scenario, the correction to a zenith angle would be as follows:

```
Datum:                    NAD 83
Latitude:                 N   40.00
Longitude:                W  108.00
Ellipsoidal Height:         2000.00   meters
Distance:                   5000.00   meters
Instr hgt:                     1.50   meters
Target hgt:                    1.00   meters

K factor:                      0.13
Zenith:                 93-30-20.000
RC:                           10.496

Zenith corrected:       93-30-30.496
```

Approximate Latitude for 2D/3D Local Horizon NE Elev Adjustments

If you intend to perform local horizon north, east, elevation based adjustment or traverse, you should provide the approximate latitude in the project area. An approximate latitude to the nearest minute or better will usually suffice.

The latitude is used to accurately model the earth's shape in the project area. **In general, this type of project should be kept to a limited extent (less than one square kilometer when possible).**

Approximate Deflection of Vertical

You can provide deflection of the vertical corrections to your Astronomic observations during a geodetic network adjustment or traverse. One way to do this is to provide different deflection values for every geodetic station. However, if you project covers a small extent, it may be easier to provide one set of deflections values for the entire project.

Deflection of the vertical corrections (whether set here or for each geodetic station) are only used in computations if the **Use Deflec Of Vertical Values** checkbox is enabled in the OPTIONS - NETWORK OPTIONS - NETWORK SETTINGS dialog.

If there are values set here (non-zero entries in SS.sss - seconds), any individual geodetic station deflection values will be ignored.

To unset default values here, enter 0.0 for both deflection fields.

Note:

Deflection of the vertical corrections are used to correct astronomic observations (those levelled in the direction of gravity) to geodetic observations (those levelled in the direction of the ellipsoidal normal) before computation. This is applicable when you wish to perform an adjustment based on ellipsoidal height (e.g., when mixing conventional and GPS measurements to compute latitude, longitude, and ellipsoidal height) not orthometric height. When performing an adjustment (containing conventional observations) based on orthometric height, you should uncheck the **Use Deflec Of Vertical Values** checkbox mentioned above.

Approximate Geoid Height

The approximate geoid height is added to State Plane and UTM ortho height in order to compute the correct Height Scale Factor (HSF) and Combined Scale Factor (CSF). These scale factors are usually based on Ellipsoidal Height.

A value within +- 2 meters is usually sufficient for the computation of HSF and CSF.

2D Height

The 2D Height settings is applicable when one of the 2D View types is active (2D Geodetic, 2D State Plane, 2D UTM or 2D Local NE) and you are performing a 2D Network adjustment, 2D COGO traverse, 2D State Plane <--> Geo transformation, 2D UTM <--> Geo transformation or 2D Local NE <--> Geo transformation.

Processing occurs in 3D space at a fixed project height. This entry should be made in the active linear units.

3D Geodetic Height

Orthometric Height

This switch is applicable to the adjustment of 3D geodetic networks, 3D COGO geodetic traverses and 3D Transformation computations based on latitude, longitude and orthometric height. When this type of adjustment is selected, the orthometric height field is used for each geodetic station. All computed vertical components will be based on orthometric height.

Ellipsoidal Height

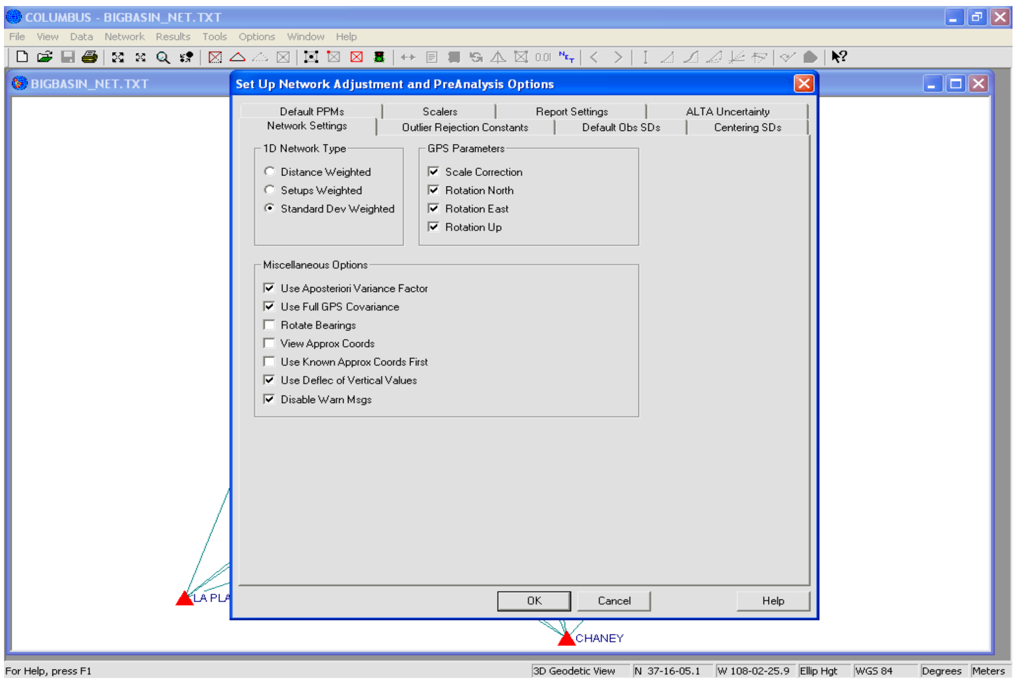
This switch is applicable to the adjustment of 3D geodetic networks, 3D geodetic COGO traverses and 3D Transformation computations based on latitude, longitude and ellipsoidal height. When this type of geodetic adjustment is selected, the ellipsoidal height field is used for each geodetic station. All computed vertical components will be computed based on ellipsoidal height.

Network Options

There are several options to apply to 1D, 2D and 3D networks. These include setting up outlier detection constants, outlier sorting methods, scale factors, instrument and target centering errors, ppm corrections for distances, default standard deviation values, and reporting options.

Network Settings

The Network Settings tab allows you to select specific 1D, 2D and 3D network modes, the inclusion of rotation and scaling corrections for GPS observables, and various other options applicable to network adjustments.



1D Network Type

The 1D Network Type option allows you to select the weighting strategy for 1D vertical networks.

Distance Weighted (between stations)

Select this option when you intend to adjust a vertical network using the **distance between stations** as the weighting strategy. With this method, as the distance between two stations increase, the weight for the observation decreases. Therefore, the observation could receive a larger correction than observations between closer stations. Using this technique, the weight for each observation is computed as:

$$weight = \frac{1}{distance}$$

Setups Weighted (between stations)

Select this option when you intend to adjust a vertical network using the **number of setups between stations** as the weighting strategy. With this method, as the number of setups between two stations increase, the weight for the observation decreases. Therefore, the observation could receive a larger correction than observations between stations with fewer setups. Using this technique, the weight for each observation is computed as:

$$weight = \frac{1}{number\ of\ setups}$$

The maximum value that can be entered in the Standard Deviation field is 30.0 meters. If you are weighting your vertical network by number of setups or distances, you may need to scale your values. For example, if your distances are in the 30 to 1000.0 meter range, divide them all by 100 and enter 0.30 to 10.0 instead.

Standard Deviation Weighted (for each observation)

Select this option when you intend to adjust a vertical network using the **standard deviation for each observation** as the weighting strategy. Using this method, the amount of adjustment applied to each observation is directly proportional to the size of its estimated variance (standard deviation squared). For each observation, the weight is computed as:

$$weight = \frac{1}{standard\ deviation^2}$$

or

$$weight = \frac{1}{variance}$$

As the variance increases, the weight decreases; therefore, the adjustment to the observation will increase. **Note: For 2D and 3D networks with leveling observations, the weighting is always based on the Standard Deviation Weighted method above.**

GPS Parameters

This switches tell COLUMBUS whether or not to perform scaling and rotation of GPS observations during a 3D network adjustment.

Scaling and Rotation

To compute scaling and rotation, you must have a minimum number of control stations in your survey:

Scale	requires a minimum of two 2D control stations
Rotation N	requires a minimum of two 2D and three 1D control stations
Rotation E	requires a minimum of two 2D and three 1D control stations
Rotation Up	requires a minimum of two 2D and three 1D control stations

There are many ways to satisfy these minimum requirements. For example, two 2D control stations are automatically satisfied by two 3D control stations. Two 2D and three 1D control stations are satisfied by three 3D control stations, etc. If these criteria are not satisfied, you can still attempt to perform scaling and rotation by overriding the warning messages during network adjustment.

Scaling and rotation of GPS baselines often leads to better adjustments to the existing network of control stations in the project area. Generally, GPS satellite observations are based on the WGS 84 datum. If the vectors from this datum are adjusted in a non-WGS 84 datum (for example, NAD 83) **and** the origins of the two coordinate systems coincide, then (ideally) the scaling and rotation parameters will be statistically close to zero. If the estimates of the scale and rotation angles are significantly different from 1.0 and zero respectively, this could be an indication of network distortions in your local control.

In most countries the local reference ellipsoid does not coincide with the WGS 84 coordinate system; for example, the Bessel ellipsoid is commonly used in Europe. This creates a problem unique to GPS measurements if the adjustment is to be computed on the local ellipsoid. Because the two mathematical systems do not coincide, the X, Y, and Z axes are not in parallel (WGS 84 X is not parallel to Bessel X, WGS 84 Y is not parallel to Bessel Y, and WGS 84 Z is not parallel to Bessel Z). Since the X, Y, and Z axes are not aligned, the measured WGS 84 GPS delta X, Y, and Z vectors will not be aligned with Bessel. While it is true the magnitude of any vector is the same regardless of its 3D space, the orientation of each vector is not the same.

In order to use WGS 84 GPS vectors in a network based on a local ellipsoid (Bessel, NAD 27, etc.), the GPS Parameters option variables must be selected so that the vectors are scaled and rotated into local space vectors. COLUMBUS can scale and rotate all GPS vectors to best-fit the local control during each iteration of the least squares adjustment. The method used by COLUMBUS is well-documented by the National Geodetic Survey (NGS) in the United States.

A best-fit rotation for delta X, Y and Z observations is determined from the control stations in your survey. The more evenly distributed your control, the better the computed scale corrections and rotation will model the network as a whole. The rotations are not based on the origin of the local datum, but rather a mean position (expressed in latitude and longitude) for the project area. This mean position is computed from the 2D and 3D control stations in your network.

The scale correction applied to each baseline can improve the fit of each GPS vector to the local control. It is important to remember that the local control is never perfect. Each control station is in error relative to the other control stations. By applying scale corrections and rotation to your GPS observable, you are simply attempting to fit your measurements to the accepted control in your project. This option is frequently utilized when computing the final constrained adjustment for a network.

Miscellaneous Options

Use Aposteriori Variance Factor

This option sets up the usage of the calculated *a posteriori* variance factor for statistical analyses in network adjustments. One of the fundamental properties of least squares adjustments is the ability to compute a scaler (*a posteriori* variance factor) which quantitatively describes how realistic the *a priori* variances (standard deviations squared) are for some or all observations in the current adjustment. Some software systems compute a Reference Factor or Standard Error of Unit Weight. These are merely the square root of the variance factor. The *a posteriori* variance factor is equal to the sum of each weighted residual squared divided by the degrees of freedom in the network.

If a chord distance has a standard deviation of 0.005 meters, but receives an adjustment of 0.050 meters, it may be assumed that the standard deviation is not realistic or a serious blunder exists. The *a posteriori* variance factor is a measure of this internal consistency **for the entire network**. In general, as the *a posteriori* variance factor statistically approaches 1.0, the network is considered to be internally consistent with the errors expected. When the *a posteriori* variance factor is statistically different from 1.0, the network is inconsistent with the variances that describe the expected precision of the observations.

If the *a posteriori* variance factor is statistically greater than 1.0, the *a priori* variances (standard deviation squared) for each observation are probably too optimistic (i.e., they are set too small). If

the *a posteriori* variance factor is statistically less than 1.0, the *a priori* variances for each observation are probably pessimistic (i.e., they are set too large).

When a network is adjusted, the Chi Square test is performed to determine the likelihood that the network is inconsistent. If so, the Chi Square test will fail, thus indicating a problem. The solution to this problem is beyond the scope of this manual. However, in many cases the problem can be corrected by scaling the variances for each observation, then re-adjusting the network. Since the *a posteriori* variance factor is a number expressing the consistency of the entire network, in some cases it can be used to correct the network inconsistency. This is accomplished by setting the A Priori Variance Scaler (see the "Network and Observation Scalers" section later in this chapter) equal to the *a posteriori* variance factor, then re-adjusting the network.

The point of this discussion is to show how the statistical results will vary as the computed *a posteriori* variance factor changes. To force the statistical results to be identical regardless of the computed *a posteriori* variance factor, enable this option. This will eliminate the need for re-adjustment if the *a posteriori* variance factor is statistically different from 1.0 (unless you are attempting to flag **possible** outlier observations by Test 2 described in the "Outlier Constants" section later in this chapter). If this option is not selected, the computed *a posteriori* variance factor will not be applied to the statistical results, and a re-adjustment should be performed until the test passes.

It is important to remember that if the *a posteriori* variance factor is determined to be statistically different from 1.0, changing the A Priori Variance Scaler will make the test pass. However, this is not always the best approach, because the A Priori Variance Scaler scales the *a priori* variances for **all** observations. Within your network, there might only be a few observations contributing to the problem (e.g., GPS observations). You should attempt to find these observations by using the outlier detection tests. **For most users, this option should be enabled.**

Full GPS Covariance

Enable this option to use the full variance - covariance 3 x 3 matrix to weight each GPS baseline. If this option is not enabled, only the diagonal entries (variance of delta X, Y and Z) will be used to weight the baseline. **For most users, this option should be enabled.**

Rotate Bearings

If you are using bearings in your network, this option will apply. If your bearings between stations pairs are mean bearings, this option should be enabled to rotate them back to a true azimuth during the network adjustment. A mean bearing is defined as:

$$\frac{\textit{forward azimuth} + \textit{backward azimuth}}{2}$$

Where: forward azimuth is from A to B and backward azimuth is from B to A (then converted to bearing form). If your bearings are true azimuths, do not enable the Rotate Bearings option. **Average bearings are often reported on PLSS plats. When using PLSS records to generate geodetic coordinates (as in a 2D adjustment) for existing boundary surveys, enable this option.**

View Approximate Coordinates

Select this option to view the approximate coordinates computed by COLUMBUS during an adjustment. In the initial steps of an adjustment, the approximate coordinates are computed and displayed for your review. You can then Keep the approximate coordinates to the project and/or continue with the adjustment.

Use Known Approx Coords First

For some projects, it may be best to let COLUMBUS compute the approximate coordinates from the known selected control stations and observations (option unchecked). However, sometimes COLUMBUS may not be able to compute good approximate coordinates for all stations by using just the control stations. When this happens, enable this option before adjustment (or traversing) to tell COLUMBUS to use **any** stations with known approximate coordinates (not just control stations) to help compute other unknown approximate coordinates. If you have provided approximate coordinates for all your stations, then enabling this option eliminates the need for COLUMBUS to compute them at all.

To define known approximate coordinates for a **geodetic** station, simply provide the approximate coordinates (lat/lon) using the $GEO or $GEO_COMPACT record in the ASCII (Text) file or by editing the geodetic coordinates through the DATA - STATIONS - Geodetic dialog. COLUMBUS will then use these supplied geodetic coordinates as the initial starting solution for an adjustment or traverse.

A user provided geodetic coordinate has a non-zero latitude or longitide value. Geodetic stations with latitude and longitude of zero are considered to unknown.

To define known approximate coordinates for a State Plane station simply provide the approximate coordinates (north/east) using the $STATE_ELEV_COMPACT record in the ASCII (Text) file or by editing this coordinate type in the DATA - STATIONS - State Plane dialog.

A user provided local NE coordiate has a non-zero north or east component. State Plane NE stations with north and east of zero are considered to unknown.

To define known approximate coordinates for a UTM station simply provide the approximate coordinates (north/east) using the $UTM_ELEV_COMPACT record in the ASCII (Text) file or by editing this coordinate type in the DATA - STATIONS - UTM dialog.

A user provided local NE coordiate has a non-zero north or east component. UTMl NE stations with north and east of zero are considered to unknown.

To define known approximate coordinates for a Local NEUE station simply provide the approximate coordinates (north/east) using the $LOCAL_NEUE_COMPACT record in the ASCII (Text) file or by editing this coordinate type in the DATA - STATIONS - Local NEUE dialog.

A user provided local NE coordiate has a non-zero north or east component. Local NE stations with north and east of zero are considered to unknown.

Use Deflection of Vertical

Enable this flag to turn on usage of deflection of the vertical information contained within your geodetic defined stations. This gives you an easy way to enable/disable this data as needed. Deflection of the vertical information is used to correct astro-geodetic observations to geodetic observations. This usually has the greatest impact the zenith angle.

For many projects, you may not have deflection of the vertical information and the relevant fields will already be set to zero (resulting in the same effect as having this flag disabled).

Note:

Deflection of the vertical corrections are used to correct astronomic observations (those levelled in the direction of gravity) to geodetic observations (those levelled in the direction of the ellipsoidal normal) before computation. This is applicable when you wish to perform a 3D Geodetic adjustment based on ellipsoidal height (e.g., when mixing conventional and GPS measurements to compute latitude, longitude, and ellipsoidal height) not orthometric height. When performing an adjustment (containing conventional observations) based on orthometric height, you should uncheck the **Use Deflec Of Vertical Values** checkbox mentioned above.

Disable Warn Messages

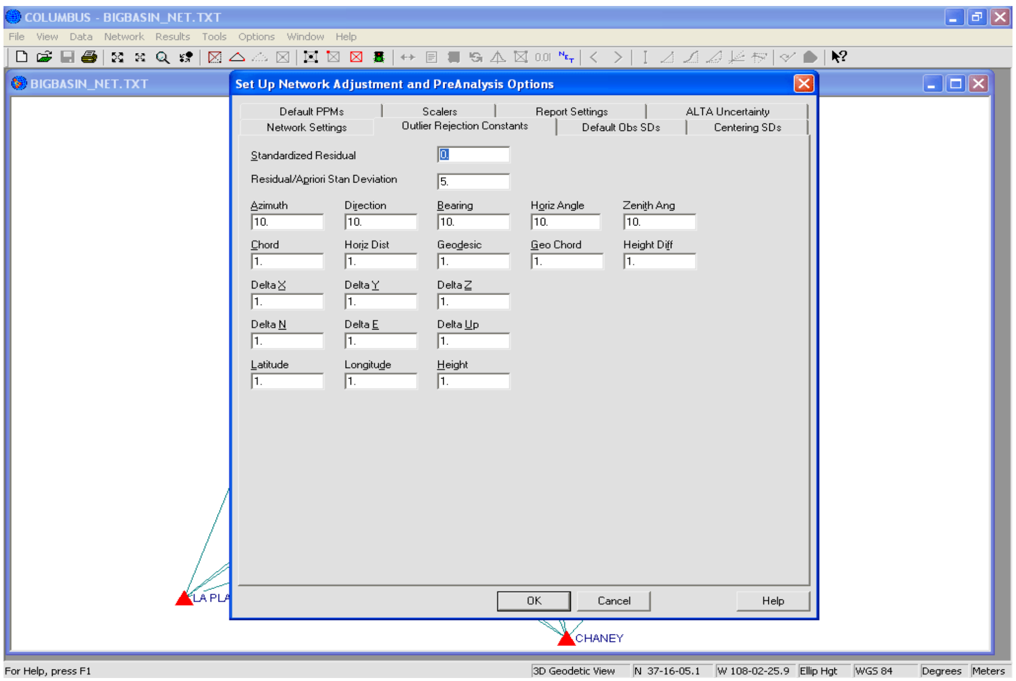
Enabling this option will result in warning messages not being displayed during adjustment or traversing.

An example of a warning message would be the indicator that two or more stations are very close together or their initial approximate coordinates are very close to one another.

Outlier Rejection Constants

The Outlier Rejection Constants tab allows you to establish observation outlier rejection constants that are used to identify **possible** outliers. Outlier observations are observations which may have significant error associated with them (may have been measured or recorded incorrectly). They may be weakening your network and may require removal or re measurement.

COLUMBUS supports three separate tests to help identifying possible outlier observations. To relax a test (flag fewer observations), simply set the applicable constant to a larger value. To tighten a test (flag more observations), set the applicable constant to a smaller value.



Standardized Residual Rejection Test

The Standardized Residual Rejection Test is based on the standardized residual for each adjusted observation. After the adjustment, COLUMBUS computes the standardized residual for each observation in the network. The standardized residual is then compared against the Standardized Residual Rejection Constant. If the absolute value of the standardized residual is greater than the Standardized Residual Rejection Constant, the observation is flagged as a **possible** outlier. The standardized residual is defined below:

$$V_{si} = \frac{V_i}{STD_i}$$

Where:

V_{si} = standardized residual for the i'th observation

V_i = residual for the i'th observation

STD_i = residual standard deviation for the i'th observation

If you enter zero for the Standardized Residual Rejection Constant, COLUMBUS will compute the **TAU-MAX statistic**. This TAU statistic is a function of the number of non-spur observations (total observations - any nocheck or sideshot observations), the degrees of freedom, and alpha - where alpha is 1.0 - the confidence level setting. If the confidence level setting is 95%, then alpha is 0.05 (1.0 - 0.95). The TAU statistic was developed by Allen J. Pope of the National Geodetic Survey (USA).

The Standardized Residual Rejection test may or may not be adequate for your needs, since observations with large residuals may also obtain large residual standard deviations, resulting in small standardized residuals. This could result in the standardized residual not being flagged when the observation may be in error.

Residual / A Priori Standard Deviation Ratio Test

The second test is based on the *a priori* standard deviation (the expected standard deviation you supplied to weight the observation) and the computed residual for each observation. For each observation, this test compares the ratio of its residual and the *priori* standard deviation.

If the absolute value of this ratio is greater than the Residual Apriori Standard Deviation Rejection Constant, the observation is flagged as a possible outlier. The Residual/Apriori Standard Deviation ratio is defined below:

$$Vsd_{si} = \frac{V_i}{STD_i}$$

Where:

Vsd_{si} = Residual Apriori Standard Deviation ratio for the i'th observation

Vsd_i = residual for the i'th observation

STD_i = a priori standard deviation for the i'th observation

This test is sensitive to the *a posteriori* variance factor computed after a network adjustment. If the *a posteriori* variance factor is statistically equal to 1.0, this test is valid, since the *a priori* standard deviations are realistic. **If the *a posteriori* variance factor is not statistically equal to 1.0, the test may be misleading**. If this is the case, recompute your adjustment by setting the A Priori Variance Scaler to the *a posteriori* variance factor. This will result in your *a priori* standard deviations being scaled - which could change which observations are flagged by this test.

Observation Residual Rejection Test

This test is based on the size of the residual for each adjusted observation. If for any given observation type (azimuth, zenith angle, height difference, etc.) the absolute value of its residual exceeds the observation type residual constant, the observation is flagged as a possible outlier.

As you can see in the screen above, each observation type has its own constant (threshold).

- Angular constants should be entered in seconds (SS.sss - degree seconds or grad seconds, depending on the active angular units).

- Linear constants should be entered in the active linear units.

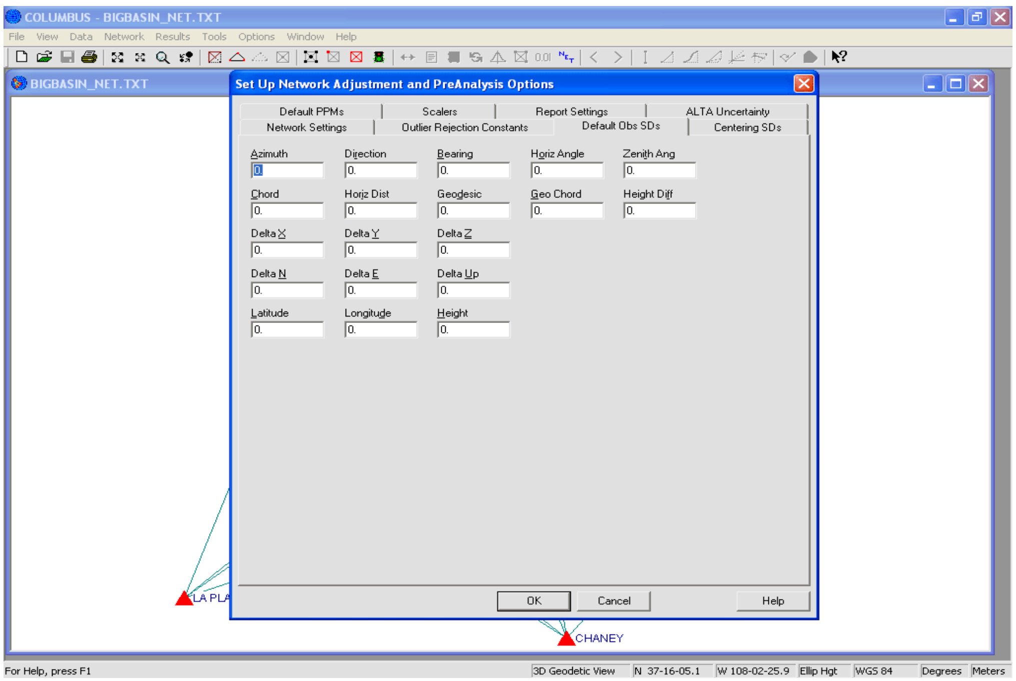
- Latitude, longitude and Height coordinate observation outlier constants should be entered in the active linear units.

When observations are flagged, they should be considered **possible** outliers. Before these observations are omitted, they should be examined carefully. In the case of GPS observations, if the Delta X observation of a baseline is flagged as an outlier, you can either remove the X component or remove the entire baseline. Usually, it is best to remove the entire baseline.

Default Observation Standard Deviations

Within this tab you can define a default observation standard deviation for any observation type supported by COLUMBUS. **Changes applied here are only applicable to a network adjustment and the computation of Datum Transformation Parameters.** They temporarily override the standard deviations for the selected observation types. **No standard deviations in the project are actually changed.**

For example, you can force all azimuth standard deviations to be 10 seconds instead of the standard deviation you originally assigned each azimuth. If this proves inadequate, you can quickly change the standard deviation for all your azimuth observations to 15 seconds, etc.



This gives you a powerful tool for performing extensive "what-if" analyses on your field data without actually changing the standard deviation data in the project.

Entries for angular observations should be entered in seconds (SS.sss - degree seconds or grad seconds, depending on the active angular units). Entries for linear observations, including coordinate observations, should be entered in the active linear units.

To override the covariance matrix for all GPS XYZ baselines, enter your own expected standard deviation for the Delta X, Delta Y and Delta Z observable. In general, if you override the standard deviation for delta X, you should also override the standard deviation for delta Y and delta Z.

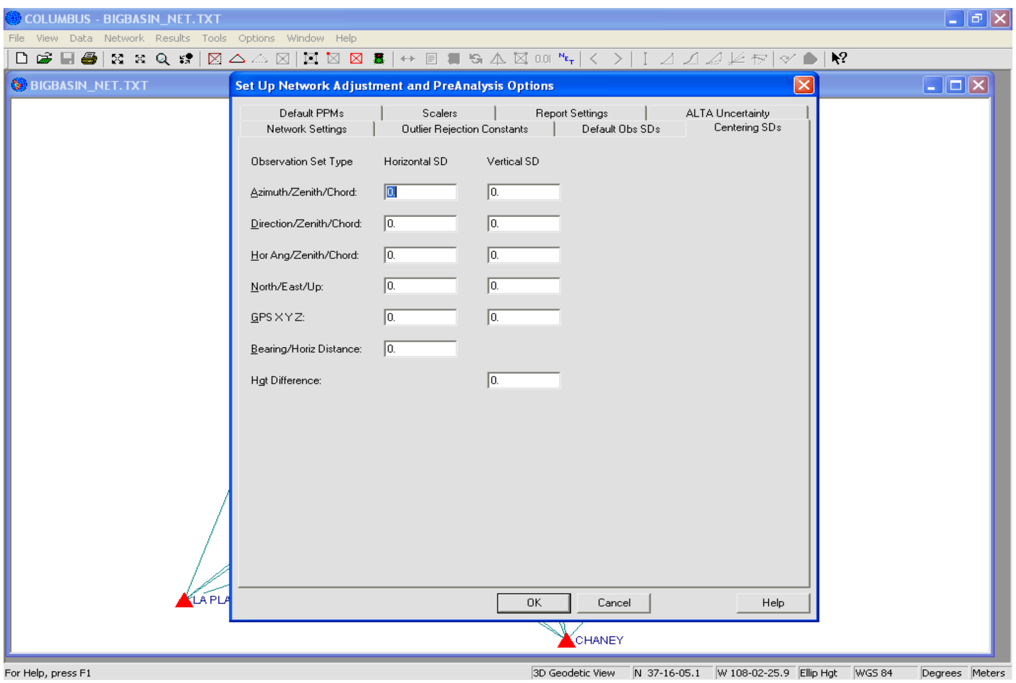
If you need to assign different global standard deviations to groups of observations, save your network data to an ASCII (Text) file and imbed the special standard deviation keywords described in Appendix A (e.g., $G_CRD_SD). These keywords can be changed any number of times within the ASCII (Text) file.

Centering Standard Deviations

Within this tab you can set up global instrument and target centering errors for differing observation sets. Entering values here automatically overrides any individual observation set centering errors.

Horizontal centering error refers to the predicted or estimated error by which the instrument and target are misaligned over the point on the ground. This value is usually very small (within millimeters). Vertical centering error refers to the predicted or estimated error by which the measured height of the instrument or target differs from its true value above/below the point on the ground. Like the horizontal centering error, the vertical centering error is usually with a few millimeters or less.

Entering centering error values greater than zero (the default) results in the corrections to the applicable observation standard deviations. This will in turn influence the adjustment results.



Enter values in the active linear units. Bearing/Horizontal Distance observation sets do not have a vertical component. Height Difference observation sets do not have a horizontal component.

Note: These global settings are only used at adjustment/analysis time and therefore do not change your original observation data in the current project. Centering errors set up here apply to both the instrument and target positions. To set different values for instrument and target positions, you should set up individual observation set centering errors. You can also set up groups of observation set centering errors within the ASCII (Text) input file format (e.g., See Appendix A, $CENTERING_GPSSET_SD and related keywords).

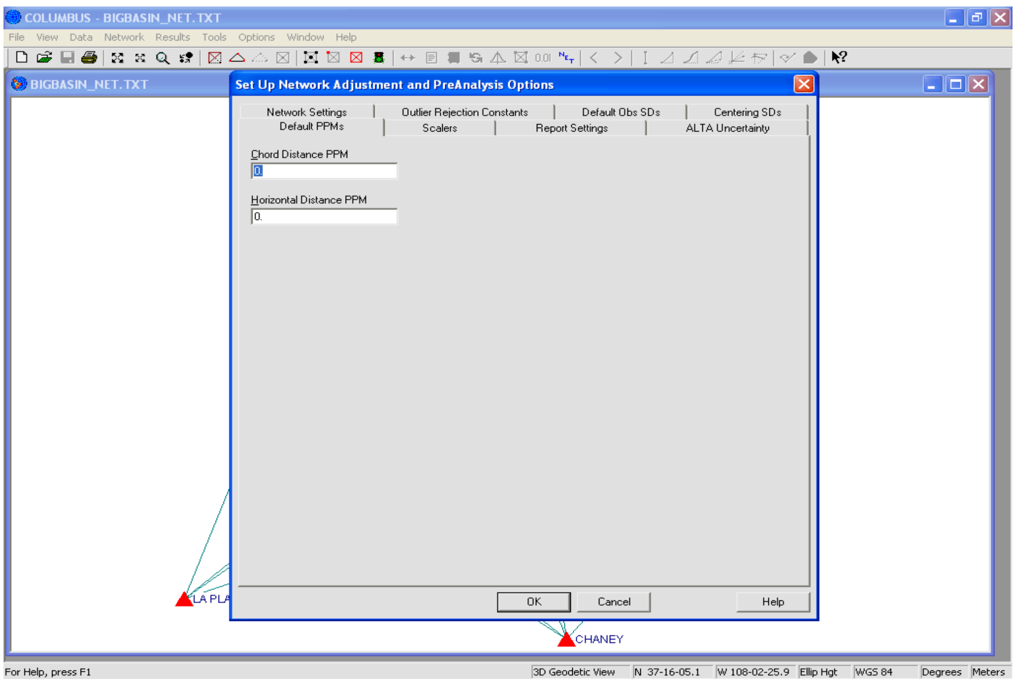
Default PPM

Within this tab you can set up global chord and horizontal distance PPM (parts per million) estimates. Entering values here automatically overrides any individual observation PPM corrections.

PPM corrections refer to the predicted or estimated errors that should be added to the current distance observation predicted errors (standard deviations) in order to arrive at the best standard deviation for the adjustment. Distance measuring instruments are usually rated at some fixed expected error + a parts per million correction. The longer the measured length, the larger the PPM correction applied.

PPM corrections should be entered as a PPM value. A PPM of 6.5 should be entered as 6.5. COLUMBUS will automatically divide this value by one million (1000000.0) before calculating the actual distance standard deviation correction.

Standard deviation correction due to PPM = Standard deviation + (PPM * distance / 1000000)

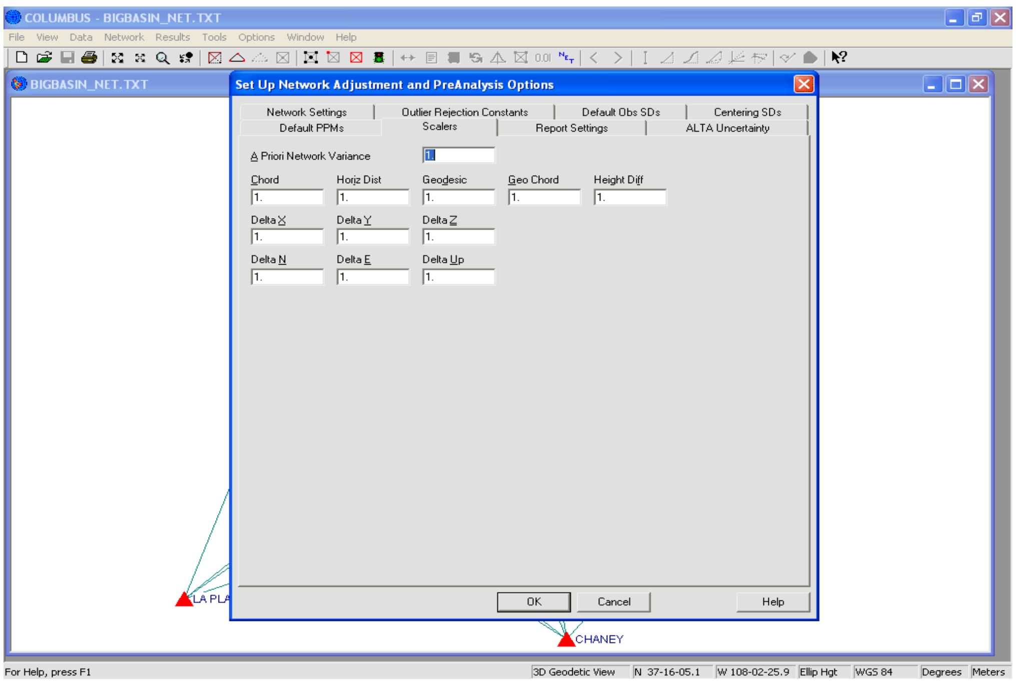


Note: These global settings are only used at adjustment/analysis time and therefore do not change your original observation data in the current project. To set different PPM values for observations, you should set up individual observation set centering errors. You can also set up groups of observation PPM's within the ASCII (Text) input file format (e.g., See Appendix A, $PPM_CHORDDIST and related keywords).

Network and Observation Scalers

Within this tab you can set up the A Priori Variance scaler for your network, and set up a scaler for each linear observation type.

The A Priori Variance Scaler is used to scale the *a priori* variance (standard deviation squared) for each observation in the network. Normally the A Priori Variance Scaler should be set to 1.0 for the initial adjustment, since the estimated variance for each observation is expected to be good. This means the variance (standard deviation squared) for all observations will be used as-is without scaling.



A Priori Network Variance Scaler

When a network is adjusted, COLUMBUS computes the *a posteriori* variance factor. The *a posteriori* variance factor is equal to the sum of:

$$\frac{weighted\ residuals^2}{degrees\ of\ freedom\ (redundancy)}$$

Based on the confidence level defined within the GLOBAL SETTINGS dialog box, COLUMBUS will test if the *a posteriori* variance factor is statistically different from 1.0.

If the *a posteriori* variance factor is statistically larger than 1.0, the predicted errors (*a priori* standard deviations for the observations) are too small for the network as a whole, and the observations were adjusted more than what was expected.

In other words, for the network as a whole, some or all observations received more adjustment (larger residuals) than expected, based on the *a priori* standard deviations for the observations.

If the *a posteriori* variance factor is statistically smaller than 1.0, the predicted errors (*a priori* standard deviations for the observations) are too large for the network as a whole, and the observations were adjusted less than what was expected.

In other words, for the network as a whole, some or all observations received less adjustment (smaller residuals) than was expected, based on the *a priori* standard deviations for the observations.

To scale the *a priori* standard deviations for all observations, change the A Priori Variance Scaler to the computed *a posteriori* variance factor, then adjust the network again. This will result in all *a priori* variances (standard deviation squared) being scaled by the A Priori Variance Scaler prior to adjustment. This is not always desirable, because you are making the assumption all observations have the wrong predicted errors. In many cases, only a subset of the observations are causing the problem.

The adjusted coordinates will be identical regardless of the A Priori Variance Scaler setting. In other words, when you adjust your network using the default A Priori Variance Scaler of 1.0, then re-adjust using an A Priori Variance Scaler of 93.0, the adjusted positions will not change. **The difference and important consideration is that the A Priori Variance Scaler directly influences all statistics associated with the network adjustment.** Therefore, it is important to properly use the A Priori Variance Scaler to get meaningful statistics, such as distance errors, error ellipses and error ellipsoids.

For a detailed discussion on variance factors and other statistical analyses, please refer to the "Papers for the CISM Adjustment and Analysis Seminars," The Canadian Institute of Surveying and Mapping, January 1987.

Observation Scalers

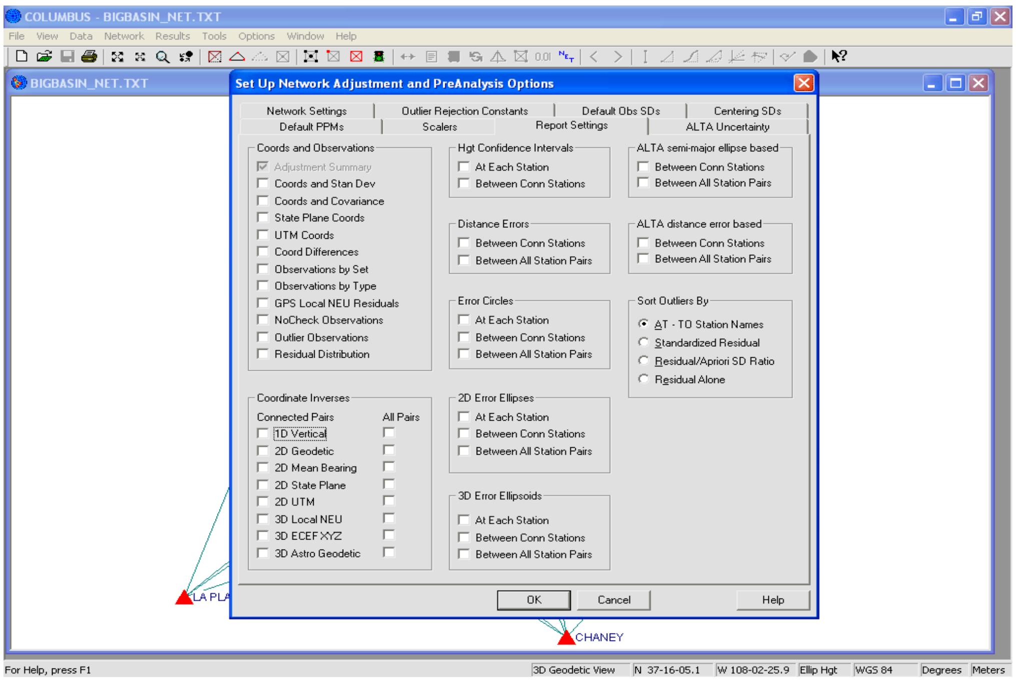
The Chord, Horizontal Distance, Geodesic, Geo Chord, Height Diff, Delta X, Delta Y, Delta Z, Delta N, Delta E and Delta Up scalers allow you to scale these observations during adjustment. This feature is useful for minimizing known systematic scale errors encountered while measuring these observation types.

Coordinate observations (latitude, longitude and/or height [orthometric or ellipsoidal]) are not scalable.

If you need to assign different global scalers to groups of observations, save your network data to an ASCII (text) file and imbed the special scaler keywords described in Appendix A (e.g., $S_CRD). These keywords can be changed any number of times within the ASCII (Text) file.

Report Settings

COLUMBUS allows you to create network adjustment and pre-analysis reports on-the-fly after each network adjustment/pre-analysis. You simply enter the desired results view and click on the **REPORT** toolbar button to send the results to a report file. You can also use the FILE - PRINT and PRINT PREVIEW commands to print individual reports for the current view.



You can also specify in advance those reports you want COLUMBUS to create automatically at the conclusion of the network adjustment or pre-analysis.

You can enable the applicable reports desired. After the adjustment or pre-analysis has completed, each report will be written into the summary view. You can then scroll down through the results, page through the results using the FILE - PRINT PREVIEW command, or save the results to an output file. To save the reports to an output file, use the RESULTS - REPORT command or click on the Report Toolbar button. COLUMBUS will prompt you for the name of a report file. All applicable enabled reports will be written to this file.

The following types of reports can be selected:

- Coordinates and Observations
- Coordinate Inverses
- Height Confidence Intervals
- Distance Errors
- 2D Error Circles and 2D Error Ellipses
- 3D Error Ellipsoids

- ALTA/ACSM Uncertainty Semi-Major Ellipse Based
- ALTA/ACSM Uncertainty Distance Error Based

For 1D vertical adjustments, only a few report types are applicable. For 2D adjustments or pre-analysis, 3D-based reports are not applicable. For 3D adjustments or pre-analysis, most reports are applicable. COLUMBUS will automatically ignore reports that are not applicable to the adjustment type.

Outliers observations can be sorted alphabetically by the AT - TO station name, or by the magnitude of the observation Standardized Residual, Residual/A Priori SD ratio or the Residual itself.

By adjusting the settings in combination with the OPTIONS - NETWORK OPTIONS - OUTLIER CONSTANTS tabbed dialog, you can create easy-to-read lists of the worst offending outliers. Because the largest offenders are listed first, they are easy to identify.

Since there are two types of observation residual units, seconds and linear units, the magnitudes can not be directly compared (when sorting by the **Residual Alone** option). For example, which is worse: an azimuth residual of 35 seconds or a linear residual of 0.05 meters? The answer depends on the length of the line. An error of 35 seconds in an angular measurement between two points 100.0 meters apart might be insignificant. However, that same error between two points 10000.0 meters apart would be significant.

For the **Residual Alone** method, sorting is based on only the residual value. Internally, the angular units are in radians and the linear units are in meters. This will result in the linear outliers tending to float to the top of the sorted list (since they will be larger). The angular outliers will tend to be near the bottom of the list.

An easy way to not mix-and-match outliers is to relax the outlier constants for the linear observation types when looking for angular outliers. When looking for linear observation outliers, relax the outlier constants for angular observation types.

The best way to look for outliers, however, is to simply open up the RESULTS - OBSERVATIONS - ADJUSTED OBSERVATIONS (or OUTLIER OBSERVATIONS) view and sort the applicable column to identify the largest offenders.

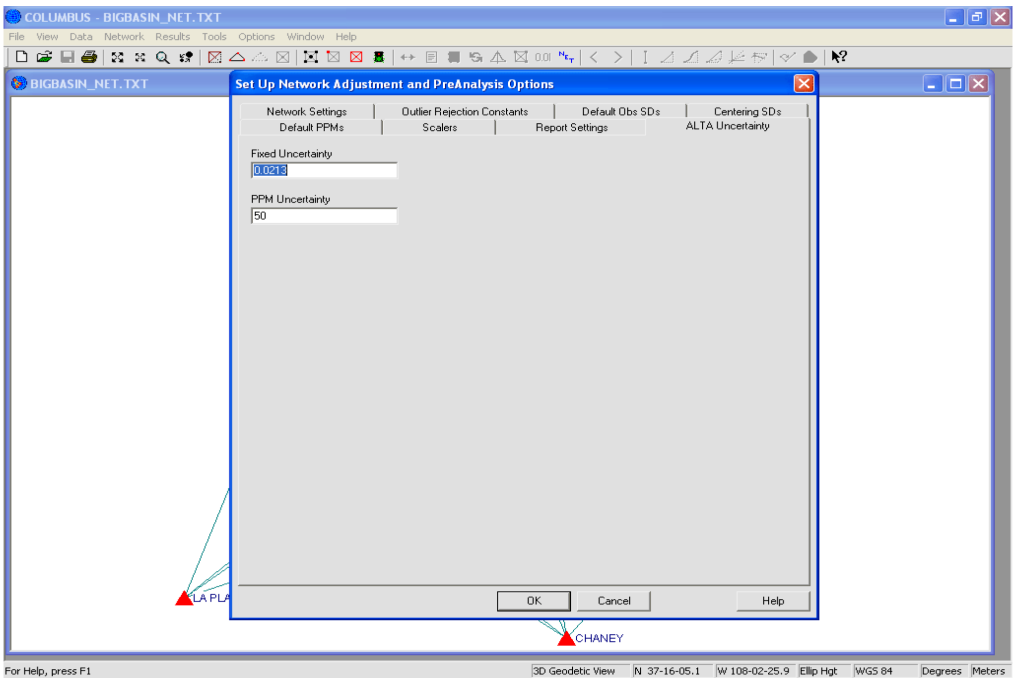
ALTA Positional Uncertainty Settings

COLUMBUS supports ALTA/ACSM Uncertainty tests. The current ALTA fixed + variable threshold is preset to 0.070 U.S feet + 50 PPM.

Where: the 50 PPM contribution = horizontal distance between the station pair * 50 / 1,000,000.0

If for some reason you want to make the threshold more/less stringent, you can directly modify the settings in this dialog.

To make the threshold less stringent, either increase the fixed portion (preset to 0.070 U.S. Feet) or the PPM value (preset to 50) or both. Do the opposite to make the test more stringent (tougher to satisfy).



Be sure you have the correct Linear Units active before entering the Fixed Uncertainty above.

Import File Setup

COLUMBUS can import coordinate files using either the OPEN, APPEND, or IMPORT - COORDINATE FILES option from the FILE menu. See the FILES chapter for more information regarding opening, appending and importing files.

COLUMBUS supports a user-defined import coordinate format. This allows you to import coordinate data for each station as a separate ASCII (Text) record. Each record is read from a separate line in the import file. Each data field is separated by the chosen delimiter (see below).

After defining the import format, proceed to the FILE - IMPORT - Coordinate Files dialog and select the files to import. Once loaded, the new project should be saved to a COLUMBUS ASCII (Text) file for future loading.

USER-DEFINED

Use this dialog to set up the User Defined Coordinate Import definition for importing existing text-based coordinate data files into COLUMBUS.

Lat/Long Format

Latitude and longitude can be imported in a variety of formats.

Given the following latitude and longitude, the possible input formats are shown below:

```
N      38 45' 35.12345"
W     105 10' 20.54321"

      DD.MMSSsssss
      38.453512345
   -105.102054321

      DD.ddddddddd
      38.759756514
   -105.172373114

      DD MM SS.sssss
      38 45 35.12345
   -105 10 20.54321

      DD dd ddddddd
      38 75 9756514
   -105 17 2373114
```

Force Quadrant Sign

This option allows you to import latitude and longitude components according to your sign (±) requirements. Internally, COLUMBUS represents eastern longitudes and northern latitudes as positive numbers, and western longitudes and southern latitudes as negative numbers. **Only one quad sign can be selected.**

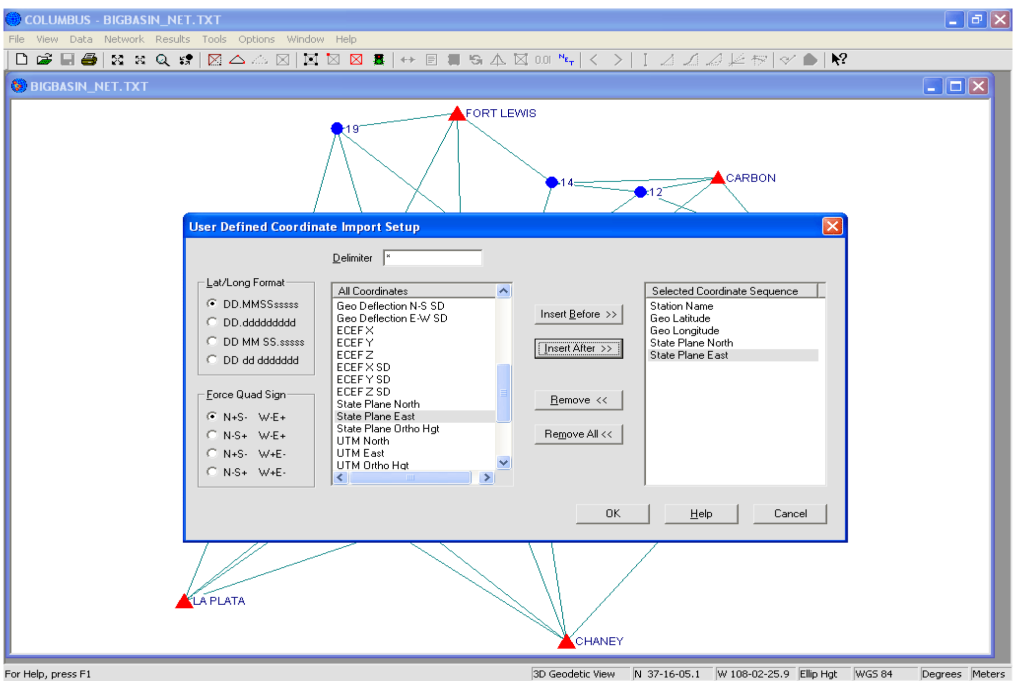
Import Delimiter

Select the delimiter character or string of characters (up to 15) used to separate the coordinate component fields. **Note: A blank space, minus sign (-) or period (.) cannot be used as a delimiter.**

Order of Station Coordinates

COLUMBUS allows you to select all the station fields to be imported for each selected station. If you select a field which does not have any entry for a station at import time, the import will fail.

To import a coordinate component, highlight it in the **All Coordinates** list, then insert it into the **Selected Coordinate Sequence** list using one of the insert buttons. The **Selected Coordinate Sequence** list must represent the import coordinate order in each record of the input file. Coordinate components that are not found in each record should be removed from the right list.



In the example screen shown above, COLUMBUS will attempt to import each of the tagged fields in the following order:

STATION NAME*LATITUDE*LONGITUDE*STATE PLANE NORTH*STATE PLANE EAST

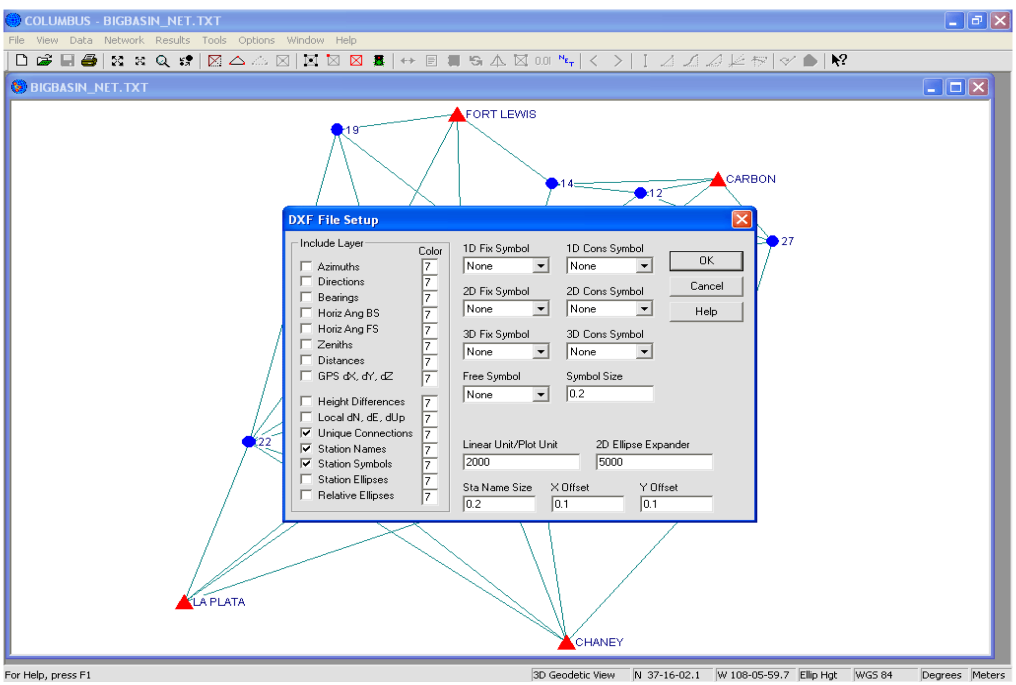
Export File Setup

With the DXF File Setup export facility, you can define the DXF file settings used when creating DXF files in the NETWORK or TOOLS modules. Using the User Defined export facility, you can define an export template for coordinate data. After establishing the export parameters, enter the USER DEFINED XPORT dialog box in the TOOLS module to select the stations to export.

DXF FILE SETUP

Within this dialog you can establish a proposed scale, thereby allowing you to dimension entities by this scale; turn on/off various layers and set their colors; size and position station names and error ellipses; and choose from an assortment of station symbols.

If you want to create your 2D or 3D geodetic network DXF file using State Plane coordinates, you can Keep your adjusted geodetic coordinates to the project, transform them to State Plane coordinates, then XPort them in the TOOLS module. Otherwise, your adjusted/analyzed networks can be sent directly to a DXF file from the Network menu.



Layers and Colors

Here you set up the layers and colors to include in the DXF file. The color number can range from 1 - 99. The most commonly used entries are 1 - 8. These numbers refer to a color scheme established in your CAD package. The first 8 colors are usually: 1 - Red, 2 - Yellow, 3 - Green, 4 - Cyan, 5 - Blue, 6 - Magenta, 7 - White, 8 - Black.

If a layer is turned on, but is not applicable (for example, the azimuth layer in a strictly GPS network), the layer is ignored. Layers are given symbolic representation in the DXF file: The azimuth layer is given the name AZIMUTH, the relative ellipses are given the name REL_ELLIPSE, etc.

All layers are applicable to DXF files created from the NETWORK module. However, you cannot export station and relative error ellipses from within the TOOLS module, since they are not available from within this module.

The Unique Connections layer allows you to export the unique connections between stations. This results in smaller DXF files for mixed networks. It also eliminates the redrawing of lines between points connected by several observation types. For example, between Station 101 and Station 102, from our BIGBASIN.TXT network, there are several different observations (horizontal angle, zenith angle, chord distance, etc.). If the Unique Connections layer is selected, and the other observation type layers are turned off, the line between Stations 101 and 102 will only be drawn once.

Lastly, it may be useful to know that each Error Ellipse (station or relative) requires approximately 170 lines in the DXF file. Therefore, if you are drawing a medium to large network with both relative and station ellipses included, the resulting DXF file will be very large.

Station Symbols and Size

This option allows you to pick various symbols for each station type (fixed or constrained, 1D, 2D or 3D) and specify the size of these symbols. You can use the same symbol for all station types or mix them up any way you choose. Similar to station name sizing, each symbol can be sized in the current Linear Unit/ Plot Unit (i.e., inches, cm, mm, etc.). All symbols are centered directly over the station when displayed.

The size context refers to stations held fixed or constrained in either 1D (height), 2D (latitude and longitude), 3D (latitude, longitude and height), or free. “Free” refers to any station not meeting the above criteria, i.e., a station which is completely floating.

Linear Unit/Plot Unit

This option allows you to set the applicable Linear Unit/Plot Unit.

You must tell your CAD package at drawing time what the Linear Unit/Plot Unit will be. The Linear Unit/Plot Unit in COLUMBUS makes it easier to set up the size and offsets of station names and symbols. The Linear Unit/Plot Unit can be in any units supported by your CAD package (meters/cm, feet/inch, etc.).

For example, if you want your drawing to be 2400 feet per inch, set the Linear Unit/Plot Unit to 2400. Then, prior to plotting from your CAD package, set up the same scale factor. If you want your drawing to be 1000 meters per cm, set the Linear Unit/Plot Unit to 1000 and also do so in your CAD package.

If you have set the Linear Unit/Plot Unit to 2400 feet/inch, you can easily size the station names and symbols. If you want the station names to be 1/4 inch tall, you would set their size to 0.25. Internally, COLUMBUS actually makes them 2400 x 0.25, or 600 plot feet tall. At 2400 feet per inch, this will be 1/4 inch at plot time.

2D Ellipse Expander

This option allows you to expand error ellipses (station and relative) to suit your needs. The expansion factor will vary from project to project. For example, if you current project was completed with high precision, the 2D Error Ellipses will be small. Therefore, these ellipses may need expansion in order to appear large enough in your drawing. To get a feel for the size you need, remember that the scale factor is multiplied by the semi-major and semi-minor axes of each error ellipse.

Station Name Size and Offsets

This option allows you to set up the size and positioning of station names in the DXF drawing. Both sizing and positioning should be selected in the current Linear Unit/Plot Unit (i.e., inches, cm, mm, etc.).

USER-DEFINED

Within this dialog box you can define what fields to export and the ordering of these fields in the resulting data file. You can export coordinates into a user-defined ASCII (Text) format which is compatible with many third-party software packages.

Connect Links

COLUMBUS supports two primary user-defined export formats. The first, with Connected Links **not** set, allows you to export coordinate data for each station as a separate ASCII (Text) record. Each record is written to a separate line in the export file. Each field is separated by the chosen delimiter (see below).

The second, with Connected Links set, allows you to export stations as paired records. Paired stations are any two stations that have a common observation (i.e., a connected station pair). Within each paired record is the AT station and its selected coordinates, followed by the TO station and its selected coordinates. If a station is selected which is not paired with another selected station, that station will not be exported.

Lat/Long Format

Latitude and longitude can be exported to a variety of formats.

Given the following latitude and longitude, the possible output formats are shown below:

```
N      38 45' 35.12345"
W     105 10' 20.54321"

        DD.MMSSsssss
        38.453512345
      -105.102054321

        DD.ddddddddd
        38.759756514
      -105.172373114

        DD MM SS.sssss
        38 45 35.12345
      -105 10 20.54321

        DD dd ddddddd
        38 75 9756514
      -105 17 2373114
```

Force Quadrant Sign

This option allows you to export latitude and longitude components according to your sign (±)

requirements. Internally, COLUMBUS represents eastern longitudes and northern latitudes as positive numbers, and western longitudes and southern latitudes as negative numbers.

Export Delimiter

Select the delimiter character or string of characters to be used to separate the coordinate component fields. **Note: A blank space, minus sign (-) or period (.) cannot be used as a delimiter.**

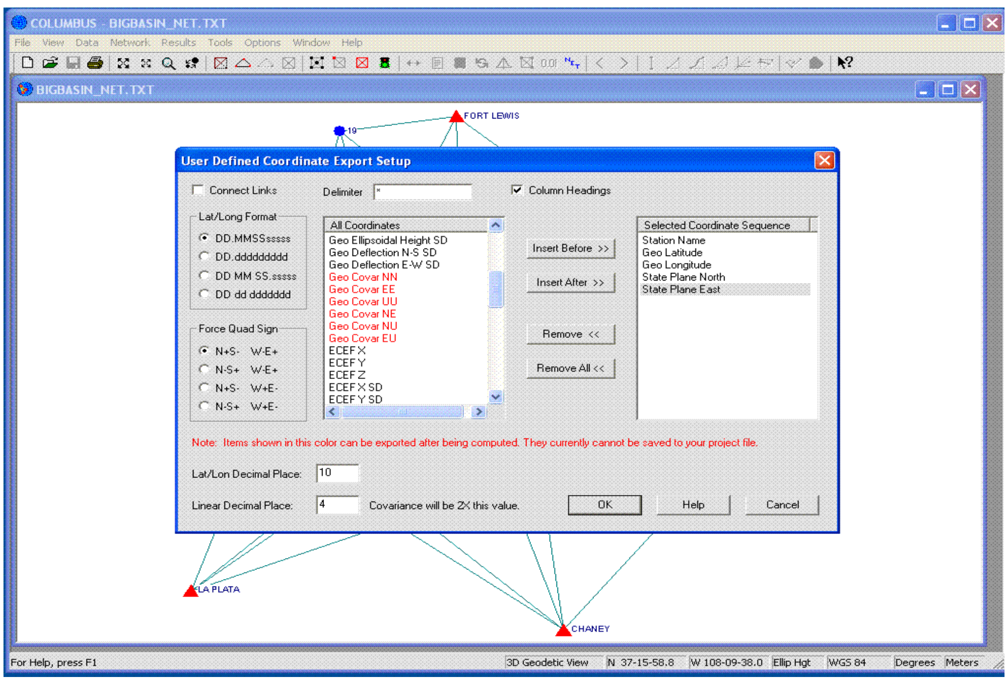
Column Headings

Export column headings to the file. Header text is the same as is shown for each field in the dialog.

Order of Station Coordinates

COLUMBUS allows you to select all the station fields to be exported for each selected station. If you select a field which does not have any entry for a station at export time, the field will be filled with the '######' symbol.

To export a coordinate component, highlight it in the **All Coordinates** list, then insert it into the **Selected Coordinate Sequence** list using one of the insert buttons. The **Selected Coordinate Sequence** list represents the export coordinate order for each record of the output file.

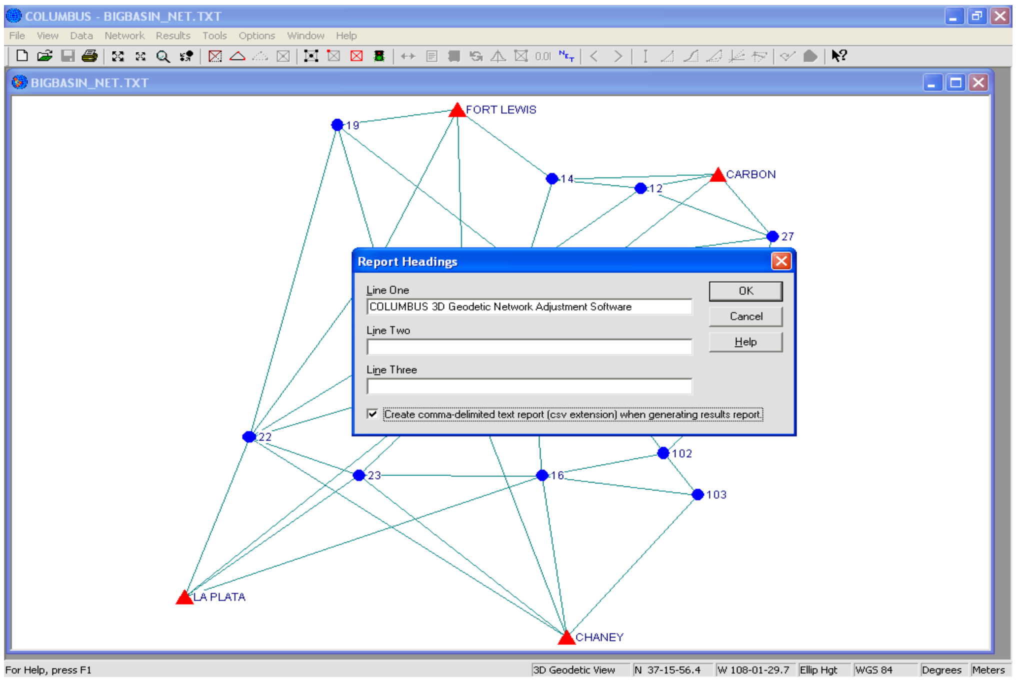


In the example screen shown above, COLUMBUS will attempt to export each of the tagged fields in the following order:

STATION NAME*LATITUDE*LONGITUDE*STATE PLANE NORTH*STATE PLANE EAST

Report Headings

Within this dialog you can enter information that you want to be written at the top of each new report file. This information might include the project name, location, description, project numbers, party chief, etc. For each line, you may enter up to 79 characters.

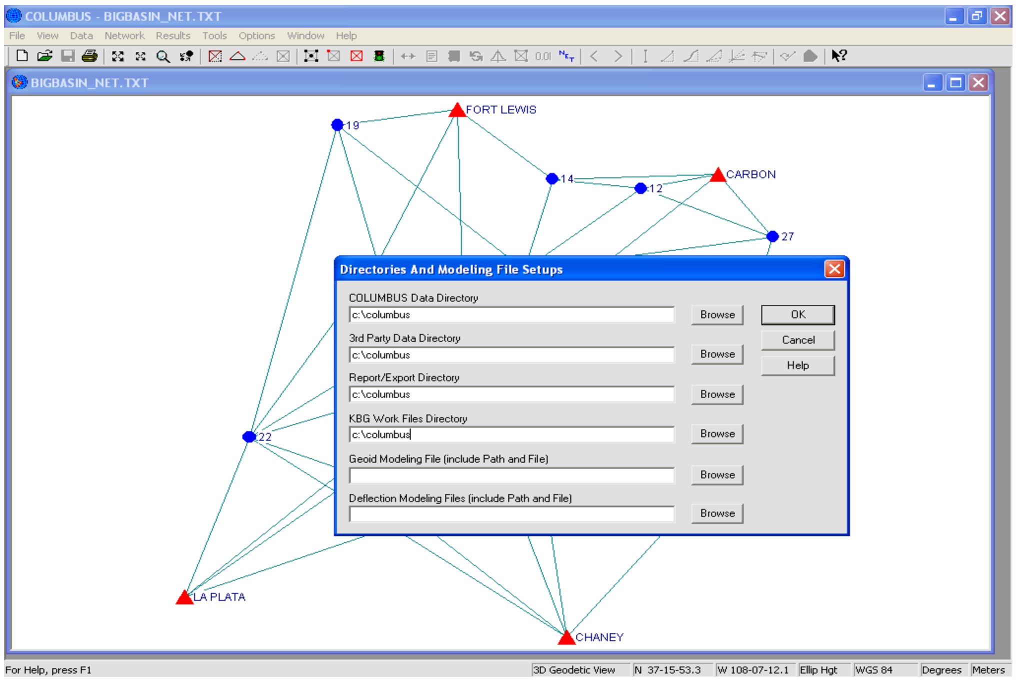


COLUMBUS also supports the ability to create a comma delimited raw report file for every report that can be generated (over 50 in all). To enable/disable the generation of comma-delimited reports, enable the “Create comma-delimited...” check box.

The comma-delimited files created using this option automatically have the same file name as the regular report file you are creating, except the extension will be *.csv. The comma-delimited file can be easily loaded into popular spreadsheet software or parsed by other third-party packages. The results contained in this file consist of the actual data only; no formatting has been added. For those users demanding sub-millimeter output, the results are often reported to more significant digits.

Directories

Within this dialog you can set up the default directories for data files, report files, work files and third-party data files, such as GPS post-processing files. If you have several disk drives, you can spread your work load across these drives by setting up a different drive plus path for each directory type.



COLUMBUS Data Directory

The COLUMBUS Data Directory input file box specifies the default location of your COLUMBUS project files.

3rd Party Data Directory

The 3rd Party Data Directory input file box specifies the location of your GPS Post-Processing and Data Collector files.

Report/Export Directory

The Report/Export Directory input file box specifies the location where your reports, DXF and user-defined coordinate export files are to be created.

KBG Work Files Directory

The KBG Work Files Directory input file box specifies the location of where temporary *.KBG files will be created. These files are created during network adjustments and network pre-analysis.

Geoid Modeling File

The Geoid Modeling File input file box allows you to define the file name for the GEOID90, 93, 96 99, 03, HT2_0 or EGM96 modeling files. Additional grids now supported include the City of Albuquerque (local grid - GC0A2008.bin) and various Canadian *.BYN grid files. **Always include the complete file name, including the extension.**

Note: The geoidal height values used in BIGBASIN.TXT were derived from GEOID93.

COLUMBUS also supports EGM 96. With this model, you can determine the geoidal height for any position on the ground throughout the world. The original coefficients are offered by NIMA in an ASCII (Text) file called WW15MGH.GRD. We have converted this file to a binary format to facilitate efficient programmatic access through COLUMBUS. The binary compressed file, EGM96DAT.EXE (about 3000K in size), can be downloaded from our Web site at http://www.bestfit.com. This file is a self-extracting archive. Run the EGM96DAT.EXE program to extract the binary grid file WW15MGH.COL (about 4000K in size).

Deflection Modeling File

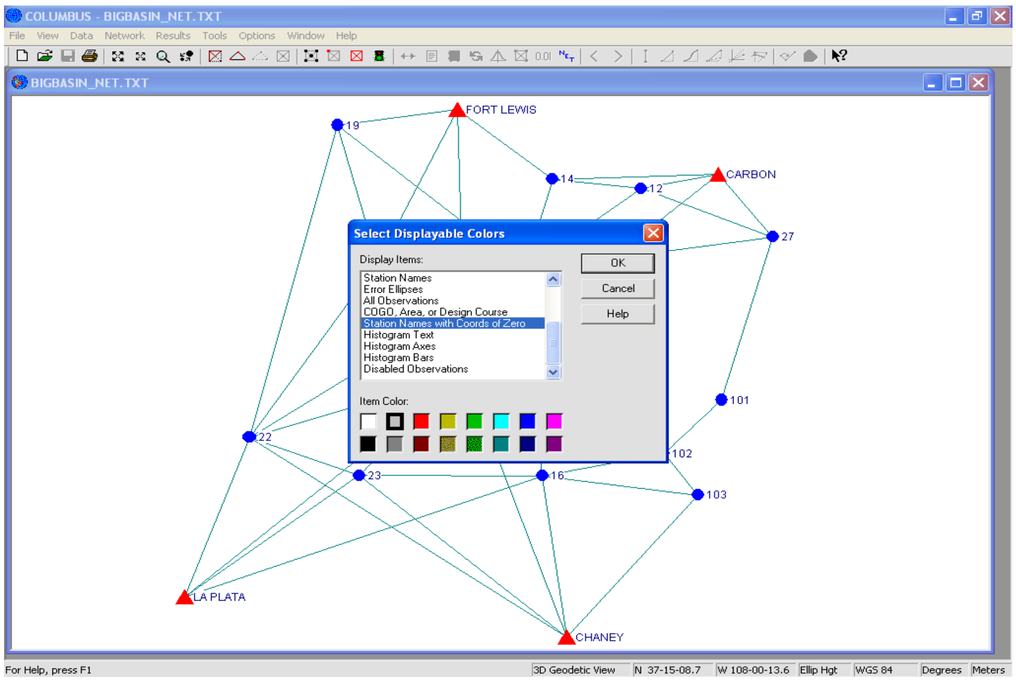
The Deflection Modeling File input file box specifies the location and file name for the paired Deflection of the Vertical modeling files. There are two NGS files required for deflection modeling; they always have the same file name, but their extensions are *.XII and *.ETA. **Do not include the extension when specifying the file name here.**

This option allows you to define the DEFLEC90, 93, 96 and 99 grid files for your region. These grid files contain deflection of the vertical data for positions within the conterminous United States, Puerto Rico and the Virgin Islands. They are applicable to geodetic coordinates based on NAD 83 or WGS 84.

The deflection of the vertical values used in BIGBASIN.TXT were derived from DEFLEC93.

Colors

Within this dialog you can set up unique or common colors for different graphical entities. For example, 1D Fixed stations can be assigned a different color than 3D Fixed stations, etc.



Non-fixed stations are those which are not fixed or constrained in any way (1D, 2D or 3D).

The **Stations Names with Coords of Zero** choice applies to a station with a latitude and longitude of zero (when in geodetic view mode) or a State Plane station with North and East components of zero, etc. Stations names with coordinates of zero are drawn in this color to make them easier to identify on screen. These stations are also automatically assigned plotting coordinates by COLUMBUS so that they will appear in the view.

Save

Within this dialog you can set up file saving options.

When the Options With Data check box is selected, the current settings in the OPTIONS module will be saved to the selected ASCII (Text) project file when you use the FILE - SAVE or FILE - SAVE AS command. When the resulting project file is later loaded, the OPTIONS settings will be restored to the way they were when the file was created.

When the Compress ASCII option is selected, ASCII (Text) files will be saved using the compressed ASCII (Text) format. Each station and observation record requires only one line in the file when using this format. For more information including format examples, see Appendix A, Compact ASCII (Text) Files. This compact format is the default format for project files.