TRAINING MANUAL
FOR

DATA COLLECTION

NOTE: This manual provides a written account of how certain activities are performed and is designed to guide and assist staff members in performing their functions.
When appropriate, there may be deviations from these written procedures due to changes in personnel, policies, interpretation, law, experimentation with different systems, or simply evolution of the process itself.

This manual may be changed at any time. Staff members are encouraged to review this manual periodically and suggest changes in the manual to keep the manual current and to minimize differences between the manual and actual practices.

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Electronic Surveying

NDDOT has a strategy for using computer-aided engineering, both hardware and software, to develop highway engineering designs. Survey data is collected in the field by using electronic data collectors. The data is then electronically transferred to a computer then transferred to the CADD editors where it is examined and edited and finally to the designer. Full utilization of the power of electronic surveying relies on the concept of a three-dimensional digital terrain model. Significant terrain features are selected, surveyed, and coded so that the computer program can digitize a representation of the existing ground. Any number of proposed highway alignments can then be investigated for cross sections, quantities, and other engineering and environmental inquiry. This chapter provides guidance on electronic data collection. NDDOT uses total station equipment and GPS equipment with electronic data collectors to obtain field data to create these digital terrain models (DTMs). Electronic surveying allows the survey crew to record and process data with very little manual data entry. The instrument person must enter the NDDOT Electronic Field Book (EFB) code for each point, point number (with out collecting duplicate point numbers in multiple data collectors), and any notes. The survey crew reviews the project and selects the most appropriate method or methods of data collection for the terrain and requirements of the job. Projects may be complete GPS surveys or supportive of photogrammetry. The traditional cross-section pattern of observation points does not produce the required level of coverage or accuracy. The digital terrain modeling (DTM) method is the required method for collecting data that will be used to develop the most accurate digital terrain model or surface. Breaklines shall be shot to best represent the ground breaks as individual lines. Spot data is shot to define gradual rolling surfaces. The DTM method allows the most versatility for collecting data, but proper coding is critical. The electronic surveying system is dependent on the use of appropriate surveying procedures in the field. Data transfer is very fast and data entry errors are greatly eliminated. However, it is a very sophisticated tool and there are times when traditional (non-electronic) surveying is needed (field books and forms). The goal is to use an efficient process for obtaining raw data, transferring it to computers, and graphically displaying the resulting survey that best represents what is in the field.

Use of a data collectors in the recording of field terrain information requires attention to standard survey practices to ensure accuracy. The lack of a paper trail (field book) can allow errors to go undetected by survey crews. The following guidelines apply regardless of the surveying method.

1. Instrument setups must be stable and solid.

2. Check shots must be taken

3. Ground truthing data collection needs to be done.

4. Accurately measure height of prism or antenna.

5. Ensure that accuracy standards are appropriate for the type of work being done.

6. Use NDDOT standard survey codes. (EFB Codes)

7. Make supplemental notes to accurately describe nonstandard items.

8. Calibrate equipment regularly.

When performing data collection make note of the following:

1. Collect breakline data in the direction of increasing point numbers. (Do not jump back on the same breakline.)

2. Make supplemental notes to further describe topography and utility items and other   none typical details

3. For ground truthing along centerline or edge strip be sure not to exceed 100 feet between shots. Take at least two cross sections per mile.

4. DTM shots should not exceed 30 feet.

5. The computer will draw straight lines between points (triangulate), so more shots must be taken on horizontal and vertical curves.

6. Do not cross three dimensional breaklines or other 3D feature lines such as asphalt and concrete.

7. Surveys & Photogrammetry personnel are available to the district to set new primary control points to replace destroyed primary control point on grading projects.

Photogrammetry

Aerial photography (stereo photos) is the basic source of information for photogrammetric surveys. The photogrammetric process is used to compile 3D surface features into a CADD drawing from the observation of aerial photographs. Aerial photography and those products it produces also have extensive use as a visual communication tool for planning, property acquisition, engineering, construction, and public relations. Features are recorded in three dimensions (x, y, and z coordinates) and topography is described by using breaklines (to describe a change of slope) and random points. These points, together with selected planimetric features, can be used to produce contours. A topographic map contains man-made features, vegetation, hydrography, and contours. A planimetric map contains man-made features, vegetation, and hydrography, but no contours. We do not place contour data on our plans, only for our own visual checks.

TERMS:

MODEL: The overlapping area of two photographs.

MOSAIC: An assemblage of overlapping photographs whose edges have been matched to form a continuous photographic representation of a portion of the earth's surface.

OBLIQUE: Lens is tilted obliquely to a point on the ground.

ORTHOPHOTOGRAPH: A photographic copy prepared from a perspective photograph in which the displacements of images due to camera tilt and ground relief have been removed.

PHOTOGRAMMETRIC SERVICES: Plotting graphic data in map form or measuring and recording data in cross section or plane coordinate forms through the use of stereo plotting instruments.

PHOTOGRAMMETRY: The science or art of obtaining reliable measurements by means of photography.

PLANIMETRIC MAPPING: Includes all culture and natural features that can be defined in horizontal position, e.g., monuments, building, roads, railroads, streams, lakes, etc.

AERIAL PANEL: A target placed on the ground used to identify a ground control point with data collected in the field.

STEREO-PLOTTERS: An instrument used by the photogrammetrist to view photographs in three dimensions in the production of maps and cross sections.

VERTICAL: Lens points straight down. Photo looks like a map.

WING POINT: A ground control point located away from the center of the aerial flight line.

Aerial panel placement

When Surveys and Photogrammetry requests the placement of aerial panels (targets) several conditions need to be considered.

Remember that the pin located at the elbow of the aerial panel is the monument that will be measured for all three coordinate values, X, Y and Z. Consequently, the pin needs to be located precisely at the inside point of intersection and also have its top surface level with the surrounding ground surface. This is because the pin is not actually visible to the stereo-plotter operator when the panel is shot from the aerial photograph. The operator assumes that the elevation recorded for the pin is the same as the immediate surface within the legs of the panel. The X and Y coordinates are also assumed to be recorded at the inside point of intersection of the aerial panel layout.
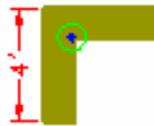
2-Leg Aerial Panel

Aerial panels are placed at specific locations based on mathematical distances from, and along, the flight line. There is a certain amount of flexibility as to where the panels end up being placed however, as the ground surface and conditions surrounding the panel, need to be carefully controlled.

Panels should be placed away from any structure or plant material that may obstruct the vertical viewing of the panel from the aircraft. Indeed, any building or tree positioned too close to a panel may cast a heavy shadow that would obscure the visibility of the panel, so think ahead!

Panels should not be placed on sloping surfaces unless there is no other option. This is because any deviation away from the center of the panel would produce a vertical displacement also. Virtually no surface is perfectly flat, so there will always be a certain element of slope in each location but the severely sloping sides of a roadway ditch would not be a good location for an aerial panel.

The surrounding vegetation should also be cleared prior to setting an aerial panel. Clear an area at least 6' in radius from the monument in the center of the panel. Use a scythe or "weed whacker" to trim the brush or grasses, as close to the surface as possible. Treading down the grasses can also help if the flight is to be made within a few days.

In general, painted aerial panels are created with white paint on asphalt and concrete surfaces. However, it is preferable to use yellow paint if it is available. In special circumstances, black paint can be used on light concrete. The reason for using different colors, is to produce a contrast between the aerial panel and the surface on which it is placed. Yellow is less reflective than white, so the surface texture can be seen more clearly with the yellow panel.

See Appendix A for the aerial panel layout diagram.

TSC2 Overview

This portion of the manual is only a brief overview of the TSC2 data collector menu structure.

Main Screen

The main screen has the following main selections and commands in it's window:

Files:

New job
        Open job
        Review current job
        Point manager
        QC Graph
        Map of current job
        Properties of current job
        Copy between jobs
        Import/Export
        Send ASCII data
                Receive ASCII data
                Create ASCII file
                Custom ASCII file
        Windows Explorer –

Key In:

> Points
> Lines
> Arcs
> Roads
> Notes

Configuration:

> Controller
>> Language
>> Sound events
>> Bluetooth
> Feature and attribute Libraries
>
> Survey Styles

GPS	Conventional
Survey Styles	Survey Styles
Rover options	Instrument
Rover radio	Laser rangefinder
Base options	Topo point
Base radio	Stakeout
Laser rangefinder	Duplicate point
Topo point	tolerances
FastStatic point	Traverse options
Observed control	
point	
Rapid point	
Continuous points	
Stakeout	
Site calibration	
PP initialization	
times	
Duplicate point	
tolerances	
Directory	
Options	

Dial Profiles

Options
About Trimble Survey Controller
       Version
       Build
       Serial number
       Authorization key
       Software warranty expiry

Survey:

This lists Survey Styles in the controller and following commands after a style is selected.

GPS	Conventional
Start base receiver	Station setup
Start survey	Station setup plus
Measure points	Resection
Measure laser points	Station elevation
Continuous topo	Measure topo
Station and offset	Measure laser points
Measure	Measure rounds
Stakeout	Continuous topo
Stakeout	Surface scan
Points	Station and offset
Lines	Measure
Arcs	Stakeout
DTMs	Stakeout
Roads	Points
Site calibration	Lines
Initialization	Arcs
Swap base receiver	DTMs
End survey	Roads
	Start Robotic
	End survey

Cogo:

Compute inverse
Compute point
Compute area
Compute azimuth
Compute distance
Compute average
Subdivide a line
Subdivide an arc
Transformations
Traverse
Taped distances
Calculator

Instrument:

GPS	Conventional
Satellites	Electronic level
Receiver files	Direct Reflex
	Turn to
Import from receiver	Joystick
	Tracklight
Export to receiver	Autolock and Search
Position	Controls
Receiver status	Instrument settings
Receiver settings	Radio settings
Navigate to point	Adjust
	Survey
	Controller Basic Trimble functions

Primary Control Points

 The positions of the Primary Control Points (PCP) for a highway project are determined by GPS Static survey methods utilizing the CORS (Continuously Operating Reference Stations) system with OPUS solutions. These PCP are generally interspaced every 2 to 3 miles along a project corridor and should be placed well outside of the project construction limits to avoid being disturbed. We also prefer to establish them on high ground which increases the range of the base radio transmission.

The minimum monument required for a PCP is a #6 x 18" rebar w/aluminum cap stamped with the point designation. They are normally numbered from west to east or south to north depending on the highway direction. An example would be along ND Hwy 32, running from Oriska to the north. The proper designation, from south to north, would be "GPS 32-1", "GPS 32-2", etc.

PCP coordinate positions control ALL other points set during the preliminary survey or construction phases and should not be changed. If level circuits need to be run, they must originate at these PCP or from RTK points subsequently set from these PCP. Most of the Districts, with their recent purchases of GPS equipment, now have the capability of establishing secondary control points where they are needed.

NEVER INTER-MIX DATUMS! For example, do not run levels utilizing the published elevations from an NGS benchmark and expect to match the elevation of the OPUS-derived PCP. In the near future, these NGS benchmarks, HARN network points, etc. will be adjusted to match the CORS network.

See Chapter 19-1.1 to 19-1.3 of the "Scope of Work for Consultants Performing Preliminary Highway Surveys" manual for further details on Project Control.

RTK Secondary Control Points

Secondary control points are used to densify project control from primary control points. The Primary control points are established every two or three miles and additional survey points are required for Total Station surveys.

Secondary control positions are established by using GPS Real Time Kinematic (RTK), Rapid Static, and Total Station methods.

RTK is the code for a control point established with GPS RTK methods. TPI or CP are the codes used for control points established with a Total Station.

Check shots

Check shots should be taken at an absolute minimum, of twice per base station setup. One should be taken at the beginning, before any survey data is collected, and the second just before the base station is shut down.

If the base is going to be used for long periods of time, additional check shots need to be taken intermediately so survey tolerances throughout the session can be confirmed. You will have to watch PDOP's, high RMS values, length of time for the setup etc. to know how many check shots are needed. The more check shots per base set up, the more comfortable you, and the editors are in knowing the data is accurate.

If you know you are going to be in an area where there are no close GPS or RTK control points, then set something nearby before you start collecting data. This may be a temporary set PK nail, chiseled 'X' or even a previously shot water valve, R/W monument or property corner.

It will be up to the field surveyor to know if a check shot is good or not. This depends entirely on what is being located. If boundary points like section corners are being located, horizontally the check shot should be very tight. If the session is for utility lines, then the elevation difference may be accepted higher than normal. If culverts are being located, then elevations need to be very close. Remember, check shots are for the field surveyor to use. If you feel comfortable with the difference, and can back them up when questioned by office personnel, then continue surveying. If they are outside your tolerance, then you may have to stop, re-initialize, go back and re-shoot critical points. Of course, if you are taking double shots on an item, notes must be recorded in the field book stating which point you feel is good, and why it was re-shot. You may even want to delete the first shot. Typically the first thing to check with a bad check shot is the base setup.

Limits of Survey - RTK

As stated in the segment "Primary Control Points" (PCP), the control points are usually set every 2 to 3 miles. With the GPS base set on a given PCP, the extent of survey should NOT extend beyond the next PCP in either direction. In this way, you can cover approximately 5 to 6 miles on each base setup. This also allows for you to leapfrog the base and set on every other PCP. For example, if you were to set the base on GPS2, you would then begin your work by checking GPS1. You could then proceed to survey from GPS1 to GPS3, where you would do another check shot before ending. You could then move your base setup to GPS4, start with a check shot at GPS3 and proceed to survey to GPS5, ending with another check shot, etc., etc.

It is imperative that you do check shots intermittently during the survey time frame. At the very least, do a check shot at the beginning of a session & before the base is shut down at the termination of a session, preferably on 2 different known points. If you are running on the same point all day, you need

to do additional check shots throughout the day. We cannot stress enough the importance of doing check shots. CHECK! CHECK! CHECK! & you will save yourself many headaches. Also, be sure to store these check shots as CHK1, CHK2, or whatever the PCP no. because this will be your only permanent record of the validity of your data. If you see a problem with a check shot, don't ignore it and proceed, discover the cause.

A majority of survey issues involve problems associated with elevation critical data (targets, culverts, railroads, bridges, etc.). This is the main purpose in establishing 'limits of survey'.

Limits of Survey – Total Station

Total stations represent a different problem. Because of the trigonometric calculations utilized in total station reductions, elevations are not as accurately obtained using these instruments. Therefore, for elevation critical data, total station measurements should NOT exceed 600 feet from the instrument.

Horizontal data is usually not a problem and can be measured at a much greater distance than vertical data.

Traverses, vertical as well as horizontal, should always be closed, again, preferably between 2 different unknown points. No traverse should ever be left open!

Remember, as in RTK surveying, check shots are absolutely necessary to maintaining the integrity of the data collected and, again, should always be stored as the only permanent record of this fact.

DTM and other 3D Feature Data Collection

Field personnel may be required to collect features and information for inclusion into three dimensional drawings, used for design plans and calculations. Collecting accurate three dimensional coordinates for features is an everyday occurrence for NDDOT crews but when features are to be included into design plans, or when surface digital terrain points are to be collected, certain requirements need to be upheld.

Be sure and understand where the digitized origin of the feature is supposed to be located. An example would be a curb inlet. Should it be shot in the center of the drain, the flow line of the gutter or the furthest point from the curb? Are trees, posts, poles and signs shot at their centers or the **nearest point to the highway**?

When collecting curb and gutter line strings, are you shooting in the correct direction? Is it roadway to left ….or **right**? Do you shoot the **top face** of curb or the flow line? What about valley gutter? **Flow line** or inside edge? Are tree boundaries shot clockwise or **counter-clockwise**?

When collecting feature lines along a project corridor, be sure and use the correct Linking Codes. Are you starting a new line string? Are you on a curve? When you select the EFB code, does the feature line have a numeric option for size or type?

Surveys and Photogrammetry editors often request additional, or replacement, surface data …or "DTM" data. Frequently these points are located in obscured areas, such as bodies of water or areas under heavy tree cover. Even those areas in the shadow of tall buildings may be obscured from the stereo-plotter operator's view.

Collecting DTM data in the field is a lot harder than collecting (or "compiling") data in the stereo-plotter. Subtle changes in surface elevation are not as easily located on the ground as they are from an aerial perspective. Surveys and Photogrammetry will sometimes be able to supply actual three dimensional coordinates to navigate to specific locations …. Or they can provide "background maps" for the data collectors, so that areas of coverage appear on the screen. However, sometimes the field surveyor is left to his/her own devices and has to collect DTM data based on their understanding of the requirements.

In the situation where a highway ditch has been full of water, the field surveyor will need to shoot a breakline along the lowest point of the ditch. They will then need to ascertain how best to "describe" the slope and curvature of the ditch profile. If they choose to shoot a "top of ditch" breakline on both sides of the previously shot flow line, the result will just be a giant "V" … not a good thing! Instead, there needs to be interim shots taken (breaklines) along the ditch line, depicting the gradual transition of the ditch slope. In most cases, a "top of ditch" and a couple of transitional breaklines on each side will produce a nice graduated profile.

If there are "unusual" deviations from the regular slope profile, additional breaklines should be collected to depict this change. If the area to be collected includes a culvert outlet, the breaklines should depict the flow line entering the culvert mouth and the immediately surrounding scour and ditch walls.

The majority of field collected DTM data will be breakline data. The breakline basically depicts "an obvious edge of elevation change." When we process the DTM data, a breakline will force the computation to hold a triangle edge along the breakline. Triangles are not allowed to cross over a breakline!

DTM spots are a useful feature to collect when the ground surface is almost flat or gradually undulating. A pasture, a farmyard or somebody's back yard or lot, would be described using DTM spots every 30' in a grid-like pattern. Once the field ends and it rolls into a ditch, a breakline would define the transition roll off line. DTM spots are connected by triangle legs, just like the breakline vertices; but in the case of spot data, the calculation will join them by finding the next nearest point only. It is not restricted as to where the triangle side can go.

See Appendix B for examples of photogrammetry and data collection products.

NOTE: At no time shall "Continuous Point" or "Rapid Point" options be used when collecting data! PDOP shall not exceed 6 (we prefer 5) and no project GPS calibration is to be performed. The Topo Point option is to be used and set at a 10 second shot with 7 measurements.

Establish Existing Highway Alignment

Determination of Reference Point (RP) stationing

The beginning point of a survey is normally at or near the intersection of two highways. This point has a known Reference Point (RP) station. Locate or establish this intersection. If there are any other highway intersections on the PROJECT, locate or establish them. Each of these highway intersections have known RP stationing AHEAD of the intersection. Therefore, there will be an equation at each highway intersection. This equation is determined by measuring the distance from the last highway intersection. Contact NDDOT, Surveys & Photogrammetry for the correct RP stationing of highway intersections on or near the project.

Establish existing alignment

The existing alignment is established by locating existing PI's, POT's, curve points, and Public Land Survey system (PLSS) corners, using existing highway plans, right of way plats, city plats, and GLO plats. The alignment must be shown on the MicroStation/Geopak CADD drawings and the associated GPK file needs to be included.

Monumentation of existing alignment

Place an Iron Pin 5/8" or 3/4" in diameter and at least 18" long at all points that will be set on the survey centerline. This will include at least all PI's, Section corners, Quarter corners, section line crossings, and quarter line crossings. Section corners and Quarter corners must be set by the procedure described in Chapter 19, Section 19-7.

Locate Property Corners

When the highway project goes through or near a city or town, research and obtain plats of subdivisions and/or lots. Locate and tie in all private property (subdivision and lot corners) monuments within one block left and right of the survey centerline.

Airports

A notice of proposed construction must be filed with the Federal Aviation Administration on airports where the proposed construction meets the following:

      1. Any construction of more than 200 feet in height above ground.

      2. Any proposed construction that enters an imaginary line that extends from a point 200 feet from the end of the nearest airport runway, upward and outward at one of the following slopes:

            A. Slope 100:1 for a horizontal distance of 20,000 feet (3.8 miles) with the length of runway more than 3,200 feet.

            B. Slope 50:1 for a horizontal distance of 10,000 (1.9 miles) feet with a length of runway not more than 3,200 feet.

            C. Slope 25:1 for a horizontal distance of 5,000 feet from the nearest point of a heliport.

      3. Complete FAA Form 7460-1 if any of the above conditions are encountered on the project. Attachments to the form are required. One attachment is the source of the coordinate information and reference datum.

Any airport (Public or Private) within two miles of the project must be tied in to the survey centerline as follows:

Runway Centerline Alignment

Extend the centerline of the airport until it intersects the survey centerline. Monument and record the coordinates (in state plane X, Y, & Z, and Latitude & Longitude) of this point on the centerline. If the airport is PARALLEL to the highway, the above intersection point determination requirement does not apply, but the items listed below are needed.

NOTE: A Registered Land Surveyor must complete a certification document. See Section **19-21** or contact NDDOT Surveys and Photogrammetry, telephone # 701-328-2640 for sample surveyor's airport certification document.

Other requirements defined

Measure and record the following information in the project survey book:

      1. Record the distance from the near end of the runway to the survey centerline.

      2. Record the width of the runway.

      3. Record the elevations of the near end of the runway (the centerline and both corners).

      4. Record the coordinates of both the near and far ends of the runway in state plane X, Y, & Z, and Latitude & Longitude.

Locate Public Land Survey System (PLSS) Corners

Locate and tie in the PLSS (Section, quarter, etc.) Corners, on survey centerline and left and right of the survey centerline crossings. These points must show up in the MicroStation CADD drawing (CONTROL.DGN).

Corner search
Search for physical evidence at each site, including making excavations as appropriate, to look for monuments, or the features with which to substantiate the location of each corner.

Set Monument and Cap
Set a ¾" diameter, at least 18" long, monument and LS CAP at corners located but not already monumented (follow Century Code NDCC 47-20.1).

Corner recordation
Prepare and record "Corner Recordation" forms on each PLSS Corner with the County Recorder. Provide the NDDOT, Surveys & Photogrammetry with a copy of each corner recordation form (in .PDF format).

Section and quarter line crossings
Determine each section and quarter line crossing the survey centerline. This point must be in line with the PLSS corners right and left of centerline. These are alignment related points.

Section and quarter line monumentation
Set a ¾" diameter and at least 18" long, iron pin monument at each section and quarter line crossing of the survey centerline. On section lines that cross a curve, the monument shall be placed on the tangent line of the curve, not on the curve itself.

Information in survey book
Measure reference ties and sketch this information in the project survey book.

NOTE: All of Chapter 19, Section 19-7 must be done by, or under the guidance of, a ND Registered Land Surveyor.

Reference Markers
Record the coordinate location of all Reference Marker posts (formerly called mile posts) on the project and supply the coordinate (Northing & Easting) data on the 080LO_001_COORDDATA.dgn sheet as shown in Chapter 19, Section 19-20.

Tie Right of Way Markers/Monuments

Locate and record the coordinate location of any right of way markers and right of way monuments found on the project. Make sure to do a thorough search for monuments and tie along with a note of type of monument. Just a tie to a Marker is not sufficient.

Sign Survey

Complete sign inventory forms for all business and State signs within the survey corridor. Measure and record the location of all the above signs. Take at least one original photograph of each sign. Try to show the sign from base to face. Use SFN 50455 (3-00) "Traffic control sign inventory" form for State signs. Use SFN 13793 (4-94) "Signs within present right of way" forms for private business signs. Assemble the forms and photographs into a sign survey forms book.

See Appendix F – Miscellaneous Forms

Locate Underground Utilities

Locate and record all underground utilities (water, sewer, gas, electric, fiber optic cables, telephone, etc.). One Call should be contacted, before scheduling your survey, to locate all utilities in the project area. NDDOT employees shall coordinate these requests through Surveys and Photogrammetry before proceeding. Consultants will be responsible to make their own requests.

Following the EFB code, use an asterisks followed by the following description on your first shot of the utility or in the field book:

1. Record name, size, and type of utility.
2. Measure and record elevation of all water main and gate valves within the survey corridor.
3. Record the invert elevation, size, type, and condition of each pipe in all sanitary and storm sewer manholes. Also the rim, ring elevations, and number of rings in all manholes.
4. Sketch the direction of each pipe, entering a manhole, in the project survey book.
5. Measure and record the location, invert elevation, size and type of all culverts within the existing highway right of way or survey corridor. All measurements should be made at the outlet of the pipe. Also note if the culvert has flared ends.
6. Record notes on utility contacts, "Name, Telephone number, and date of contact" in the project survey book

RAILROAD CROSSINGS

Locations, descriptions, and details required at railroad crossings include:

Railroad equation
The measurement shall be taken at the inside of both rails. Also determine the railroad equation. Example: Highway centerline **RP** station = railroad centerline station. The railroad stationing can be determined from RR right of way or station to station plats.

Railroad profile
Get elevation profiles (centerline and top of each rail) down the RR track 1000 feet left and right of highway centerline.

Crossing type
Dimensions and type of crossing (wood plank, asphalt, concrete plank, etc.) shall be recorded in the survey book. Location and type of crossing protection (signals, gates, cross bucks, etc.) shall also be recorded in the survey book.

See Appendix F – Miscellaneous Forms

Bridge (Hydraulic) Survey Data

For any structures located on the project, the NDDOT Bridge Division needs the following minimum survey data to assist in their hydraulic analysis:

1. Complete the Bridge Survey Report form (SFN 3853). A sample copy of the Bridge Survey Report form is located in Section 19-19.

2. Upstream profile - Beginning at the upstream end of the existing structure, take and record profile shots along the thread of the stream, every 100 feet or less, going upstream 1000 feet.

3. Downstream profile - Beginning at the downstream end of the existing structure, take and record profile shots along the thread of the stream, every 100 feet or less, going downstream 1000 feet.

4. Typical upstream cross section - Take a typical cross section somewhere between 500 feet and 1000 feet upstream to adequately cover the flood plain. This may require a cross section of 1000 feet or more in length.

5. Typical downstream cross section - Take a typical cross section somewhere between 500 feet and 1000 feet downstream to adequately cover the flood plain. This may require a cross section of 1000 feet or more in length.

6. Structure site typical stream section - Take a typical profile section on both sides of the existing structure.

7. Centerline profile - Take a profile of the highway centerline through the flood plain.

NDDOT Standard Survey Codes (Electronic Field Book Codes)

Electronic Field Book Codes (EFB) need to be strictly adhered to. These are the only codes that the CADD editors software will recognize. The use of nonstandard results in unnecessary additional time to be spent fixing for the software to perform correctly. In CADD codes designate placement of if a point, symbol, or line is to be created. The EFB code list describes what each code is for and if it defines a point or line.

Spots are entered in the data collector as just the code while line codes require a "Linking Code" to create the line or in essence draw the feature in the field into CADD. The linking codes need to be a prefix to the EFB code. Following is a list of designators used:

Begin Line	+
End Line	-
Close Figure	!
Beg/End Curve	/
PC Curve	XPC
PT Curve	XPT
Curve Fit	XCF
PCC Curve	XCC
Continuation	XCN
Duplicate Prefix	XDU
Comment Char	*

GeoPak Linking Codes

Types of features

There are only two types of features that are located electronically, Points and Lines. To determine which type of feature you are locating, look in the EFB code book. The code book will give you the code, a description of the code and the feature of the code.

Point features

A "Point" feature utilizes a single shot on the item. This code will determine what type of symbol the CAD software will place at that position. An example of a point type feature is a sanitary manhole (MHS). This manhole should be located at the center of the lid. Another example would be a right of way marker / post. In this case, it is a concrete R/W marker (RWMC). This should be located on the face of the marker nearest the center line of the roadway.

Line features

The other type of feature, "Line", takes a minimum of two shots, and can have as many shots as needed to show the entire feature. The line type feature codes will instruct the CAD software to connect all the points with the same code, with the proper line style. The interval of shots will depend upon what type of line you are shooting. One example of a line type feature is a telephone fiber optic line (TFO). Normally these would start at a pedestal or box of some sort. At a minimum, take shots along this line at every change in direction. If this line runs straight for extended lengths, then intermediate shots should be taken just to show that it is indeed a straight line. The number of shots on a straight line will have to be a field judgment. Just remember that the CAD editors will definitely question a line if they do not see location shots every few hundred feet. Being that a telephone line or any type of utility line is not used in Digital Terrain Models (DTM), distances between shots can be lengthened, and changes in elevation are not important. On the other hand, for example a break line (BRK), the interval of shots should never exceed 30 feet even in flat or straight grade areas. When the terrain is rolling or you are on a steep grade of sorts, then the interval distance between shots should be smaller. Understanding what type of line feature you are locating is very important. Is it a line that is going to be used to determine the DTM? Knowing the answer will determine the interval distances between shots.

How to start and end, line type features

In order for the CAD software to know when to start and end lines, a prefix called "Linking Codes" have to be added to the code. The first position located for a line feature uses the linking code "+". This tells the CAD software to connect it, with all the following positions that have the same code, with the proper line style. The linking code "-", tells the CAD software to end that particular line style. The following is an example code used at an edge of concrete.

Linking Code	Definition	Example
+	Begin Line	+CON
-	End Line	-CON
/	Begin and End Curve	/CON
!	Close Figure	!CON

Curves

When locating a feature, that has a curve in it, a slightly different approach is taken. As before, the feature must start with a begin line "+" linking code anywhere along the tangent. When you reach the point of curvature (begin curve) the linking code "/" is added to the code. In order for the software to create a nice 3 point arc for the curve, the mid point of the features curve must be located with only the original code, then at the point of tangency (end curve) another linking code "/" is added to the code. Doing this, the CAD software with create a best fit arc starting at the first position with the "/" linking code, go through other like codes and end the arc at the position with the second "/" linking code. Continue on with the original code until you end line "-".

Close figures

The "!" linking code is a very useful item. It will close a line style to the beginning shot. It is most helpful on buildings and the like. To use close figure, the first location shot will need the "+" linking code, then the locations of the item must be taken in either a clockwise or counter clockwise direction around the item being located. When you come to the final corner of the feature being located, the linking code "!" will be added to the code. This will create a closed line style, with no gaps or overlaps. It is important to remember, that each corner must be located in sequence so the lines do not crisscross each other like an hourglass figure.

Comment Delimiter

A comment delimiter is used to give a more detailed description of what is being located. The number of characters should be limited to 10. Any additional comments or descriptions should be noted in a field book. The comment delimiter is an * symbol. Use the multiply key on your data collector to get this. What this delimiter does is lets the Micro-Station software know that the code is ended and basically to ignore anything following it. For an example a gas main line is being located, and you want to add the comment of the size and owner of the gas line. The code would be "+GM*4inMDU". This shows that the size of the gas main is four inches, and owned by Montana Dakota Utilities. Usually a comment on line type features is only placed on the first shot. All shots that relate to the same line can just contain the code. In this case "GM". If a more detailed description is needed about the feature located, then a comment "SEEFB" should be used after the *. For an example you are locating a section corner, the code and comment would be "NWSEC*SEEFB". This will tell the CADD editor that additional information about the section corner will be available in the Transit-Level book. A chapter in the field book should be reserved just for these items. When entering these extra notes in the field book, be sure to reference the point number you are describing. See example below:

356, 325298.5641, 1985621.3587, 2514.6896, NWSEC*SEEFB

#356 NWSEC Found #6 rebar with cap LS3659, SEC8 T149N R86W, 4" below
            Surface, Recorded as document number 1358 at the county. All ties checked.

#1549 +FNC Chain link fence is 8 feet tall with 3 strands of barbed wire atop.

Explanation of Culvert Codes

The EFB culvert codes need to give additional information on culverts. The condition of each end of
the culvert barrel, along with the condition of each flared end-section if applicable, will be added to the
description. e.g. +24RCPF*FP PLUGGED

The above example shows the beginning of a 24" reinforced concrete pipe with a flared end section.
The barrel is in fair condition, the flare is in poor condition, and the additional description shows it to
be plugged.

The + or – symbol denotes the beginning or the end of the culvert location. It does not matter which
end of the culvert you begin at. It can be the inlet or the outlet, as long as the code is exactly the same
for both ends.

After the + or – symbol you enter the size of the pipe (##) in inches. In the majority of the cases this
number should be in even increments. If you come across an unusual culvert like a 33", you need to
enter more information in the field book explaining the culvert so there will be no assumption of a miss
typed size.

After the size (##) of the culvert, enter the culvert type.

Culvert types:

"##CSP" corrugated steel pipe.
"##CPP" corrugated plastic pipe.
"##RCP" reinforced concrete pipe.
"##CIP" cast iron pipe.
"##PVC" poly-vinyl chloride.

If a pipe has a flared end section, an "F" is added to the end of the "culvert type" code.

"##CSPF" corrugated steel pipe with flared end section.
"##CPPF" corrugated plastic pipe with flared end section.
"##RCPF" reinforced concrete pipe with flared end section.
"##CIPF" cast iron pipe with flared end section.
"##PVCF" PVC pipe with flared end section.

This ends the actual code for the culvert.

The asterisk (*) is a delineator between the culverts code and the condition/description.

First letter after the asterisk (*) is the condition of the barrel of the culvert.

"G" represents good.
"F" represents fair.
"P" represents poor.

The second letter after the asterisk (*) represents the condition of the flared end section, if applicable.

"G" represents good.
"F" represents fair.
"P" represents poor.
"N" represents none.

In some cases, there are culverts that only have a flared end section at one end. In this case, the condition letter on the end of the culvert that does not have the flare is "N". For example, an 18" CSP, one end has a flare, and the other end does not. The barrel at one end is in fair condition, and the flared end section is in good condition, the code would be +18CSPF*FG. At the other end of the culvert, the barrel is in good condition but there is no flare the code would be -18CSPF*GN

Arch type culverts need to be addressed differently. The size of the culvert will be added to the description after the asterisk (*). As an example, "+RCPF*60x45GF". The culvert is a RCP with a flared end section, the barrel size has a 60" span x 45" rise which is in good condition and the flare is in fair condition.

Additional notes may be added as needed such as "plugged" or "too small" after the condition letters. There are times when additional descriptions for the culvert are needed, but are too long to type into the data collector. These longer descriptions should be entered in the field book. Create a chapter for "culvert details" in the field book. You can enter extra notes like "large beaver damn at inlet" or "6 foot deep scour at outlet". If there are additional notes needed, the code for the culvert should look similar to this: +24CSPF*GP SEEFB. The "SEEFB" represents (see field book). This alerts the CADD editors that additional data is noted in the field book and they can then look up the information. When entering these extra notes in the field book, be sure to note the point number, size and type of culvert you are referring to.

The following are examples of how the culverts are to be coded.

A 24" RCP with flared end sections, the barrel is good and the flares are poor on both ends of the culvert.
Pt. #,   Northing,   Easting,   Elevation,   Code *Description
5001, 501564.0258, 2489254.6578, 2500.5468, +24RCPF*GP
5004, 501568.1258, 2489220.4578, 2501.0254, -24RCPF*GP

A 36" CSP with no flares and is in good condition, but one end is plugged.
Pt. #,   Northing,   Easting,   Elevation,   Code *Description
489, 506245.3658, 2478658.2498, 1645.2451, +36CSP*G
490, 506290.2456, 2478651.1254, 1647.2541, -36CSP*G PLUGGED

Found one end of a 6" PVC culvert in good condition, but could not locate the other end.
+6PVC*G SEEFB. Then in the field book under "Culvert Details", enter the point number of the

culvert along with a description of the situation;   #542 a 6" PVC was found as an outlet. Could not locate the inlet end, but it could possibly be a roof drain outlet from the nearby building at 1903 N State St.

See Appendix C for EFB Code listing.

Point Number Ranges

Data management is a critical part of data collection. It is necessary to keep from having duplicate point numbers. It is important to adhere to a standard set of point ranges. If a you are to be working on a project that has already been started you will need to contact those people to find out what point number range is still available. Following is a standard list of point ranges:

Numbering System			
Numbers	Point Range Information		Typical User
1-99	Existing	Alignment	Survey – Photo
100-5999	Existing	Primary/Other Control	Survey – Photo
100-5999	Existing	Earth	Survey – Photo
100-5999	Existing	Public Land Survey System (Section Data)	Survey – Photo
100-5999	Existing	Photo Panels (should be same # as called out on panel layout)	Survey – Photo
100-5999	Existing	Topog	Survey – Photo
100-5999	Existing	Utility	Survey – Photo
6000-7999		Property Lines and Right of Way	ROW
8000-8999	Proposed	Alignment – Office Location	Design
9000-9999	Proposed	Topog Info (curb returns, sidewalk, control points, etc)	Design
10000-10999	Proposed	Utilities – Drainage	Design
11000-11999		Bridge	Bridge
12000-13999		Testing and Sample Locations	Materials and Research
14000-14999		Construction – Change Orders – As-Builts	District
15000-19999		Reserved for CADD Standards Development	
20000-34999	Existing	Survey Data Overflow	Survey – Photo

NOTE: At no time shall "Continuous Point" or "Rapid Point" options be used when collecting data! PDOP shall not exceed 6 (we prefer 5) and no project GPS calibration is to be performed. The Topo Point option is to be used and set at a 10 second shot with 7 measurements.

Field Books

It's a common misconception that with electronic surveying, field books are not needed. Field books are still a vital part of surveying and can help reduce the number of questions on the "Whatiz" sheets and therefore the number of revisits to a project.   The field book should be clearly labeled on the cover and first inside page. The label should contain the project number, name, and date of project. The first pages should contain the following: table of contents, site maps, control point data, alignment points, section corners, utilities, section corner and alignment ties, and miscellaneous notes. The field book should keep this order as much as possible as to keep it uniform for ease of finding items from one project to another. Any non-typical items should be addressed in the miscellaneous notes if they do not fall under one of the other topics.

See Appendix E for field book example.

Preliminary Survey Request for additional information – "Whatiz Sheets"

During the process of the preliminary survey, questions will arise that need to be answered by a field visit. These questions are usually presented in the form of printed sheets or PDFs. The questions come from several sources but usually originate from items that can not be identified by the stereo plotter operator. There is some data that is necessary on all surveys that is easier to provide on the question ("Whatiz") sheets.

Questions originating from the aerial photography can vary from Utility items to surface types to additional DTM data. In most cases "Yes", "No", and "Done" are not normally acceptable answers to the questions. An example of this may be "Is this a post". Just answering no will not suffice. An explanation is in order. For instance a good answer would be "No – R\W Mkr – 3456". This would let us know that the point is in fact a Right of Way Marker and was shot with EFB point number 3456. Along those same lines if the post happened to be a telephone pedestal then the pedestal should be located along with the utility lines that run to or from it. It could be that there is no longer an item at the location in question. If this is true then the field personnel should provide their best explanation as to why. Some examples of this might be "Found broken R\W Mkr laying near location" or "Evidence of old fence line – Removed"

In all cases it is better to be generous with explanations than stingy! If the answer is too short it could cause weeks of delay in a project's completion and days of extra work on both the part of the Cadd Editor and Field personnel. It is a good idea to have a working knowledge of the project extents and purpose while answering the questions. This will better assist you in giving an answer that will reduce

the chance of an additional field visit. More often than not the answers given or data collected on the Whatiz sheets pose additional questions that require more field visits. A good example of this is the post question above that turns out to be a telephone pedestal. We will need the telephone lines that

enter and exit this pedestal. If they are not picked up then an additional field visit will be required.

The Whatiz sheets should also be used as proof sheet for the survey. All of the topographic and utility data collected by the stereo plotter and field crews will be printed on the sheets. The field personnel are responsible to make sure that the data shown on the sheets is complete. Data that is normally collected by the stereo plotter can be missed due to many reasons whether it is shadows on the photos, a tree canopy or others. Likewise during the initial field visit there is a chance that items may have been missed due to the large amount of data required to be collected or because of confusion between multiple field crews. In any case the field personnel should verify that all of the necessary data needed

for the project is shown on the Whatiz sheets.

When answering questions by writing on the printed sheets, be sure to use a pen or pencil that has a color in contrast to the printed material. A highlighter can also be used to draw attention to the answers written on the sheets. A few times in the past a pencil has been used by a person that writes very small. The answers were written in and amongst the graphics. When this is done the answer will almost certainly be missed and assumed unanswered, once again delaying the project.

The old saying a picture is worth a thousand words is still a useful expression. With today's technology it is very easy to take and relay a digital picture whether that is from a digital camera or a cell phone. If there is an item that is unusual or difficult to describe then give your best explanation along with a picture or two.

There are some items that will need to be collected on all projects. These items include curb and gutter dimensions, street names and in urban surveys the threshold elevations of buildings on adjacent properties.

See Appendix D for example of "Whatiz Sheet" and questions.

Background Maps

Background maps can be brought into the data collector in a .dxf format. It is best to eliminate any items in the drawing that are not needed to reduce the size of the file. Large files will bog down the data collector. Background maps are useful to see where you are on the project and to see where data needs to be picked up such as obscured areas. The .dxf file needs to be saved in the Trimble data collector in the Trimble data folder.

Step 1: To associate the background map with the project open the data collection software and select Files and Properties of Current Job.
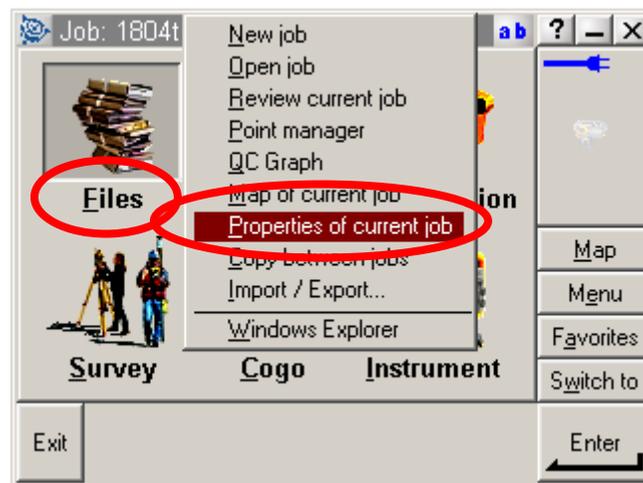
Step 2: The following window will appear. Select the Background Files tab.
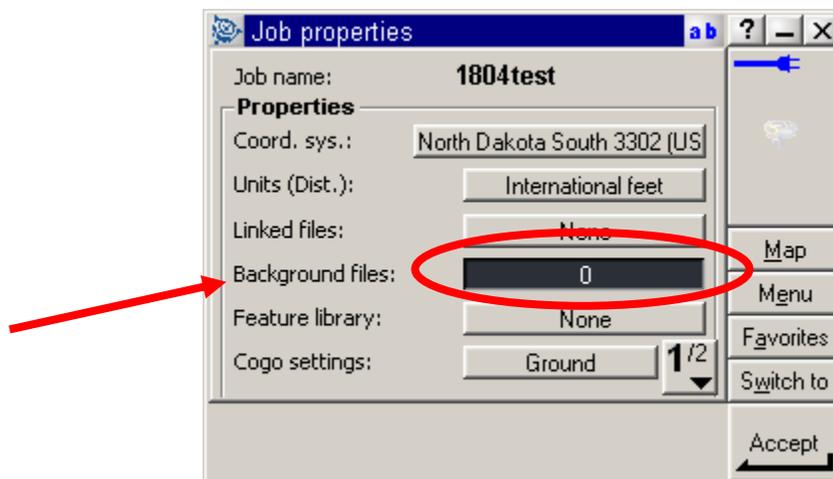
Step 3: Select the .dxf map listed for your project then select Accept.
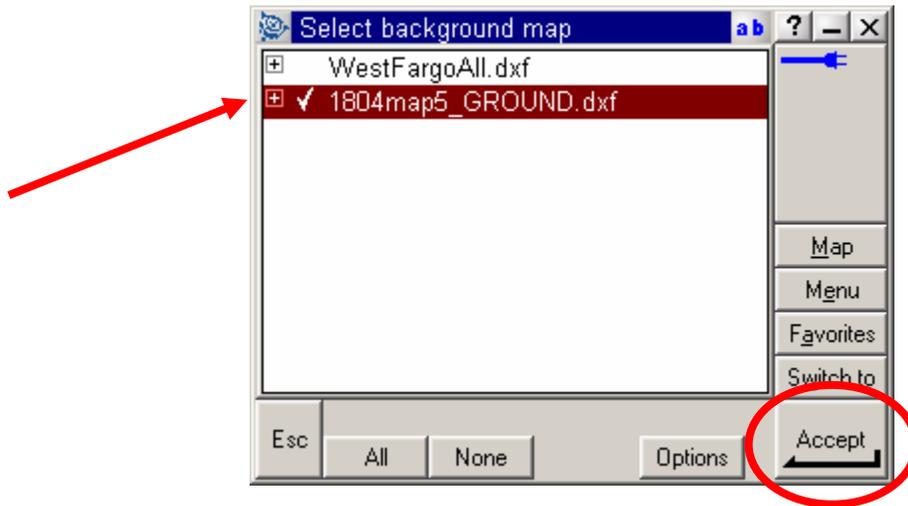
Step 4: This will bring you to your original Job Properties screen indicating the number of background files that have been linked. You will again need to select Accept.

You may then view your map by selecting Map on the right hand side of your data collector screen.
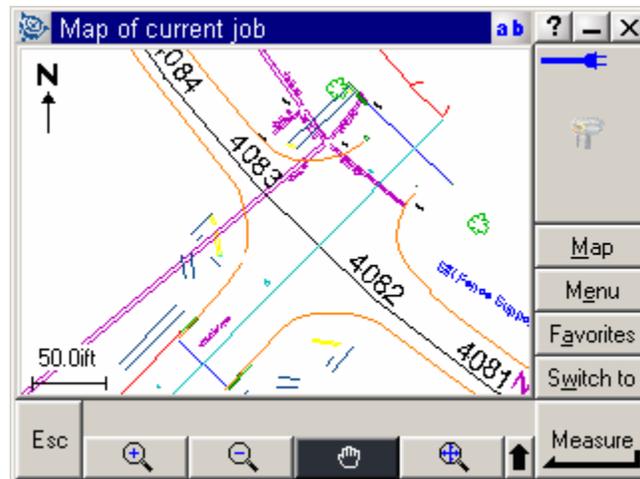
Additional options available from the Map screen.

RTK Infill Processing Procedures

When using the RTK infill process, care must be taken in the "survey style" so the raw satellite .dat files are always stored at the bases receiver and within the rovers data collector itself when "infill" is invoked.

It is very important to keep good field notes when infill is used, so the person processing the data knows what files to look for and the times infill was used. This along with metadata information is critical. In metadata (data about data), we are looking for the point number, code, and antenna information (type, height, measured to etc.).

In the field book, enter the position of the base station. Receiver information such as the serial number (last four digits), julian day, and session number = .dat file. Start and end times of the base station observation. Antenna data is critical so enter the type, height and how the height was measured, and to where the height was measured. This is also true for the points observed when infill is used. The most important of course is the point number, code, antenna height, measured to, and rough time of observation.

It is prefer to use the "Trimble Geomatics Office" (TGO) utility program "Data Transfer" (or Office Synchronizer) to download files from the "data collector" (dc) to the project folder. Download the pertinent dc file and .dat files necessary from the rover, and .dat files from the base receiver.

A project in TGO should be set up in a logical path for your project. Make sure the correct state plane zone and geoid was used. Move the dc and .dat files to the "checkin" folder.
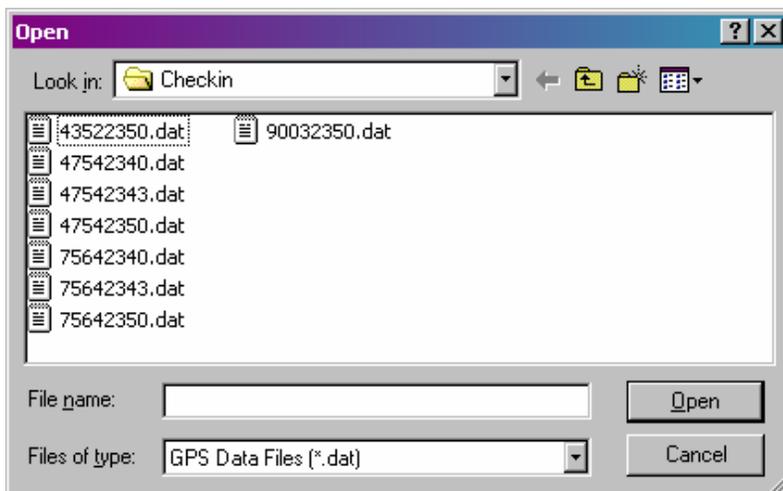
Highlight all .dat files and select "Open". The "DAT Checkin" window will open with all information on the imported .dat files. Now is the time to edit these points to match the field notes. As usual, the most critical is antenna information.

TRAINING SUBJECT: DATA COLLECTION

DAT Checkin

	Use	Name	Filename	Start Time	Stop Time	Receiver Ty	Receiver	Antenna	Antenna Type	Measured To	Feature Code
1	✓	43522350	43522350.da	09:04:16 23 Aug	13:03:31 23 Aug	5700	02202943	5.125	Zephyr Geodetic	Antenna Phase Center	
2	☐	Roving Segment	47542340.da	14:28:21 22 Aug	14:36:16 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
3	✓	3006	47542340.da	14:36:21 22 Aug	14:36:56 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	SQCOR21*GLO
4	☐	Roving Segment	47542340.da	14:37:01 22 Aug	14:38:31 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
5	✓	3007	47542340.da	14:38:36 22 Aug	14:39:06 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	WTCOR*SQ21BIA
6	☐	Roving Segment	47542340.da	14:39:11 22 Aug	14:53:36 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
7	✓	3008	47542340.da	14:53:41 22 Aug	14:54:11 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	WQCOR26*GLO
8	☐	Roving Segment	47542340.da	14:54:16 22 Aug	14:55:11 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
9	✓	3009	47542340.da	14:55:16 22 Aug	14:55:46 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	WTCOR*WQ26BIA
10	☐	Roving Segment	47542340.da	14:55:51 22 Aug	15:04:21 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
11	☐	Roving Segment	47542343.da	15:31:56 22 Aug	15:41:31 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
12	✓	3010	47542343.da	15:41:36 22 Aug	15:42:06 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	WQCOR21*RBR
13	☐	Roving Segment	47542343.da	15:42:11 22 Aug	15:44:21 22 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
14	☐	Roving Segment	47542350.da	10:08:11 23 Aug	10:18:01 23 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
15	✓	3012	47542350.da	10:18:06 23 Aug	10:18:41 23 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	SQCOR20*GLO
16	☐	Roving Segment	47542350.da	10:18:46 23 Aug	11:14:31 23 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
17	☐	3013	47542350.da	11:14:36 23 Aug	11:15:06 23 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	SQCOR19*GLO
18	☐	Roving Segment	47542350.da	11:15:11 23 Aug	11:15:26 23 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
19	✓	3013	47542350.da	11:15:31 23 Aug	11:16:01 23 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	SQCOR19*GLO
20	☐	Roving Segment	47542350.da	11:16:06 23 Aug	11:19:06 23 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
21	✓	3014	47542350.da	11:19:11 23 Aug	11:19:41 23 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	SQCOR19*GLO
22	☐	Roving Segment	47542350.da	11:19:46 23 Aug	11:20:51 23 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
23	✓	3015	47542350.da	11:20:56 23 Aug	11:21:26 23 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	WTCOR*SQ19RBR
24	☐	Roving Segment	47542350.da	11:21:31 23 Aug	11:49:36 23 Aug	5800	42451147	6.562	R8/5800/SPS780 Internal	Bottom of antenna moun	(none)
25	✓	H3712	75642340.da	09:01:06 22 Aug	12:29:06 22 Aug	5700	02202475	6.562	Zephyr Geodetic	Bottom of antenna moun	GPS3712
26	✓	75642343	75642343.da	14:05:46 22 Aug	15:51:31 22 Aug	5700	02202475	6.568	Zephyr Geodetic	Antenna Phase Center	
27	✓	H510	75642350.da	08:40:41 23 Aug	12:22:46 23 Aug	5700	02202475	6.562	Zephyr Geodetic	Bottom of notch	RTK
28	☐	Roving Segment	90032350.da	12:17:41 23 Aug	12:18:01 23 Aug	R8 Model 2	46291190	8.000	R8 Model 2/SPS880 Internal	Bottom of antenna moun	(none)
29	✓	525	90032350.da	12:18:06 23 Aug	12:18:36 23 Aug	R8 Model 2	46291190	8.000	R8 Model 2/SPS880 Internal	Bottom of antenna moun	PCR*IND ALLOT 2.
30	☐	Roving Segment	90032350.da	12:18:41 23 Aug	12:25:36 23 Aug	R8 Model 2	46291190	8.000	R8 Model 2/SPS880 Internal	Bottom of antenna moun	(none)
31	✓	526	90032350.da	12:25:41 23 Aug	12:26:11 23 Aug	R8 Model 2	46291190	8.000	R8 Model 2/SPS880 Internal	Bottom of antenna moun	PCR*IND ALLOT 2.
32	☐	Roving Segment	90032350.da	12:26:16 23 Aug	12:27:56 23 Aug	R8 Model 2	46291190	8.000	R8 Model 2/SPS880 Internal	Bottom of antenna moun	(none)

[OK] [Cancel] [Reset]

For example, above on line 1 the "name" (point number) defaulted to the receivers serial number/julian day/session. Without field notes, we have no idea where this base was setup. I am also sure that the "Measured To" field is incorrect (Antenna Phase Center). There is also no "Feature Code" entered. All these items need to be fixed before importing.

DAT Checkin

	Use	Name	Filename	Start Time	Stop Time	Receiver	Receiver	Antenn	Antenna Type	Measured To	Feature Code
1	✓	H13	43522350.dat	09:04:16 23 Aug	13:03:31 23 Aug	5700	0220294	5.125	Zephyr Geodetic	Bottom of notch	H13DM
2	☐	Roving Segment	47542340.dat	14:28:21 22 Aug	14:36:16 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
3	✓	3006	47542340.dat	14:36:21 22 Aug	14:36:56 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	SQCOR21*GLO
4	☐	Roving Segment	47542340.dat	14:37:01 22 Aug	14:38:31 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
5	✓	3007	47542340.dat	14:38:36 22 Aug	14:39:06 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	WTCOR*SQ21BIA
6	☐	Roving Segment	47542340.dat	14:39:11 22 Aug	14:53:36 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
7	✓	3008	47542340.dat	14:53:41 22 Aug	14:54:11 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	WQCOR26*GLO
8	☐	Roving Segment	47542340.dat	14:54:16 22 Aug	14:55:11 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
9	✓	3009	47542340.dat	14:55:16 22 Aug	14:55:46 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	WTCOR*WQ26BIA
10	☐	Roving Segment	47542340.dat	14:55:51 22 Aug	15:04:21 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
11	☐	Roving Segment	47542343.dat	15:31:56 22 Aug	15:41:31 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
12	✓	3010	47542343.dat	15:41:36 22 Aug	15:42:06 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	WQCOR21*RBR
13	☐	Roving Segment	47542343.dat	15:42:11 22 Aug	15:44:21 22 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
14	☐	Roving Segment	47542350.dat	10:08:11 23 Aug	10:18:01 23 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
15	✓	3012	47542350.dat	10:18:06 23 Aug	10:18:41 23 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	SQCOR20*GLO
16	☐	Roving Segment	47542350.dat	10:18:46 23 Aug	11:14:31 23 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
17	☐	3013	47542350.dat	11:14:36 23 Aug	11:15:06 23 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	SQCOR19*GLO
18	☐	Roving Segment	47542350.dat	11:15:11 23 Aug	11:15:26 23 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
19	✓	3013	47542350.dat	11:15:31 23 Aug	11:16:01 23 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	SQCOR19*GLO
20	☐	Roving Segment	47542350.dat	11:16:06 23 Aug	11:19:06 23 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
21	✓	3014	47542350.dat	11:19:11 23 Aug	11:19:41 23 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	SQCOR19*GLO
22	☐	Roving Segment	47542350.dat	11:19:46 23 Aug	11:20:51 23 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
23	✓	3015	47542350.dat	11:20:56 23 Aug	11:21:26 23 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	WTCOR*SQ19RBR
24	☐	Roving Segment	47542350.dat	11:21:31 23 Aug	11:49:36 23 Aug	5800	4245114	6.562	R8/5800/SPS780 Internal	Bottom of antenna mount	(none)
25	✓	H3712	75642340.dat	09:01:06 22 Aug	12:29:06 22 Aug	5700	0220247	6.562	Zephyr Geodetic	Bottom of antenna mount	H3712
26	✓	H3712	75642343.dat	14:05:46 22 Aug	15:51:31 22 Aug	5700	0220247	6.562	Zephyr Geodetic	Bottom of antenna mount	H3712
27	✓	H510	75642350.dat	08:40:41 23 Aug	12:22:46 23 Aug	5700	0220247	6.562	Zephyr Geodetic	Bottom of antenna mount	H510
28	☐	Roving Segment	90032350.dat	12:17:41 23 Aug	12:18:01 23 Aug	R8 Model	4629119	8.000	R8 Model 2/SPS880 Internal	Bottom of antenna mount	(none)
29	✓	525	90032350.dat	12:18:06 23 Aug	12:18:36 23 Aug	R8 Model	4629119	8.000	R8 Model 2/SPS880 Internal	Bottom of antenna mount	PCR*IND ALLOT 2.
30	☐	Roving Segment	90032350.dat	12:18:41 23 Aug	12:25:36 23 Aug	R8 Model	4629119	8.000	R8 Model 2/SPS880 Internal	Bottom of antenna mount	(none)
31	✓	526	90032350.dat	12:25:41 23 Aug	12:26:11 23 Aug	R8 Model	4629119	8.000	R8 Model 2/SPS880 Internal	Bottom of antenna mount	PCR*IND ALLOT 2.
32	☐	Roving Segment	90032350.dat	12:26:16 23 Aug	12:27:56 23 Aug	R8 Model	4629119	8.000	R8 Model 2/SPS880 Internal	Bottom of antenna mount	(none)

[OK] [Cancel] [Reset]

Take a look at lines 25 and 26. When first importing, line 26 did not have a point number assigned, and other metadata was missing or incorrect. After further review, the dat file on line 25 was not needed because no infill points were located during that time. On the other hand, line 26 which was actually set at the same base position as 25 had three infill observations tied to it.

Once you have edited all the "Checkin" data and went ahead with the import, TGO will show all baselines "grey" which means they are potential baselines that can be processed. They also show how they will be processed. The arrows on these baselines shows the direction of the baseline. TGO fixes these by observation times. The longer a station is collecting data, the more weight it is given. You can at this time "reverse" direction of the processing. In other words, if you have a favorite base station you feel real comfortable with, you may want to force TGO to use that point as the main point, by highlighting the baseline, right mouse click and select "Reverse Observation Flowout". Reverse "H13 – H510" to become "H510 – H13".
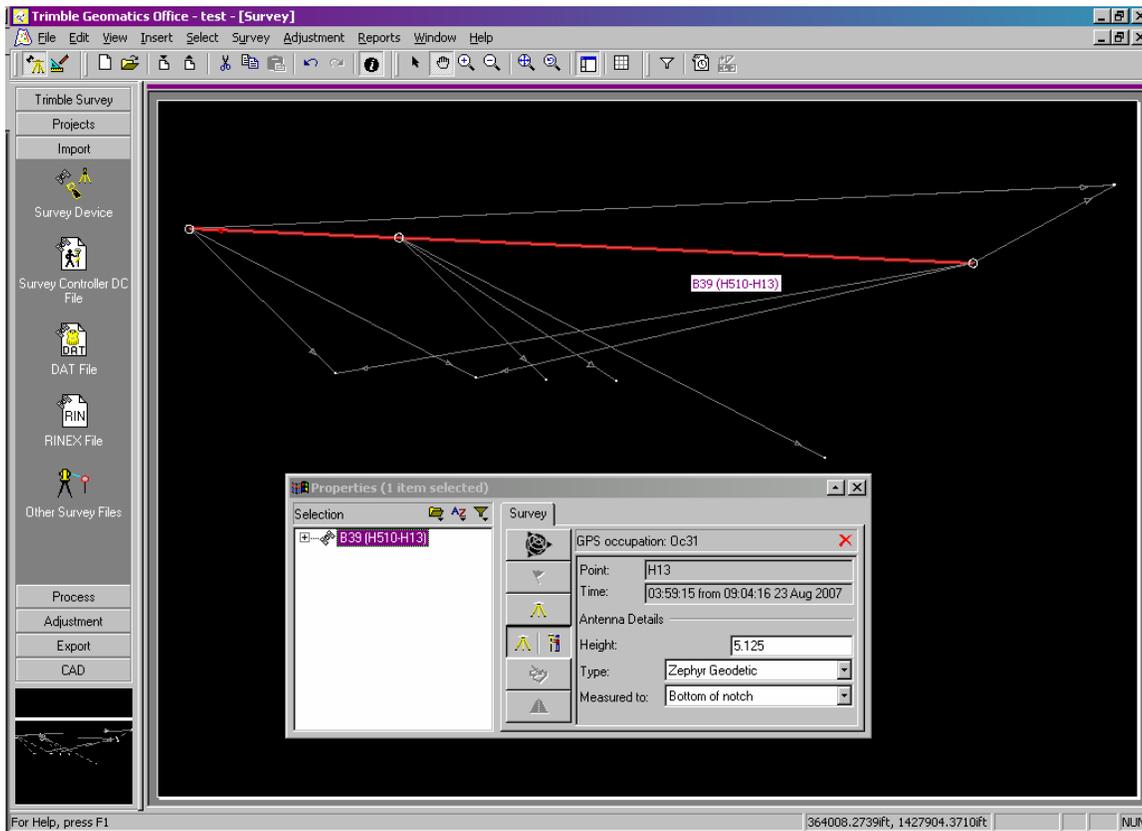
Now its time to process all baselines. You can either select all baselines, or process them individually by highlighting the one you want to process. Once you have selected the baselines to be processed, select "Survey" - "GPS processing style" - "Trimble default". Then again select "Survey" - "Process GPS Baselines".

A GPS processing window will appear with the data on the baselines. If there are any errors in the baseline, they will be rejected and other methods of processing may need to be looked at. For example changing the "elevation masks", "adjusting observation times" etc.

	ID	From station	To station	Baseline length	Solution type	Ratio	Refvar	RMS
☑	B36	H13	3013	7732.176	L1 fixed	8.7	3.617	0.004
☑	B37	H13	3014	7732.946	L1 fixed	8.7	0.763	0.002
☑	B38	H13	3015	7733.046	L1 fixed	8.7	3.200	0.005
☑	B40	H13	525	34772.511	Iono free fixed	32.7	0.389	0.008
☑	B41	H13	526	34772.486	Iono free fixed	32.7	4.234	0.017
☑	B42	H3712	3006	9803.708	L1 fixed	3.1	7.021	0.009
☑	B43	H3712	3007	9803.940	L1 fixed	3.1	3.514	0.006
☑	B47	H510	3012	19136.506	Iono free fixed	10.3	0.290	0.006
☑	B48	H510	3013	24284.300	Iono free fixed	8.2	0.533	0.006
☑	B49	H510	3014	24283.454	Iono free fixed	8.2	0.314	0.005
☑	B50	H510	3015	24283.391	Iono free fixed	8.2	0.488	0.006
☑	B51	H510	525	6071.020	L1 fixed	43.0	6.999	0.009

☑ Overwrite duplicate baseline solutions

Pending   14 Acc, 0 Rej

Things to look for here are "Solution type". If any are "float" remove them by taking the check mark out. This baseline will have to be looked at again and possibly need to be reprocessed. The two types we see here are "L1 fixed" and "Iono free fixed". Both are good solution types. The difference is because of the baseline lengths. Any baseline under 5 kilometers will be "L1 fixed", and longer baselines will be "Iono free fixed".

Next look at the "Ratio" and "Refvar". L1 fixed solutions will have to be judged differently from the Iono free fixed. The higher the ratio the better, and the closer to 1 for the Refvar the better. In this case, I would look closer at the ID "B42". We may want to reprocess this one with a different elevation mask. The rest appear to be good.

But alas, not all processed. There were three baselines (looks like two) that did not process. These remained grey in color. The blue are processed as RTK, and the yellow is processed as a "static" baseline because of the length of time.
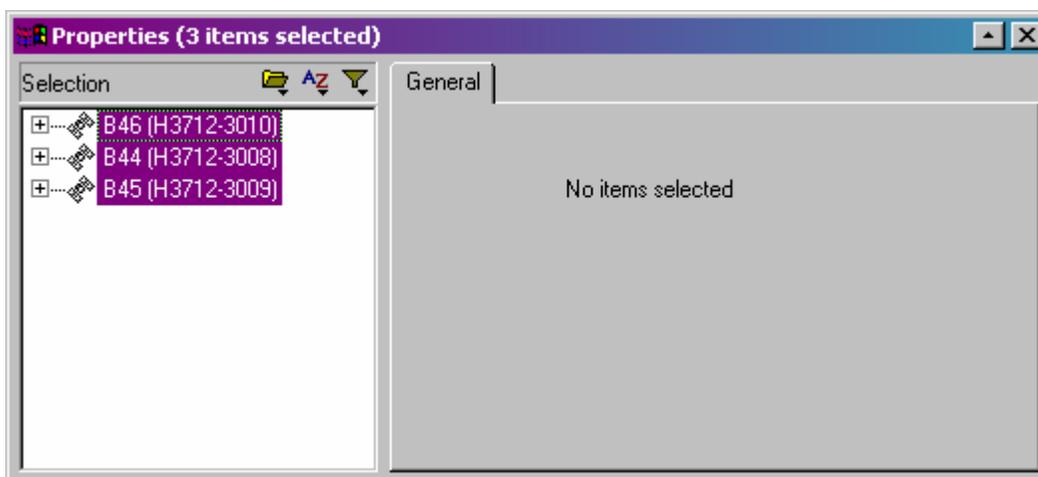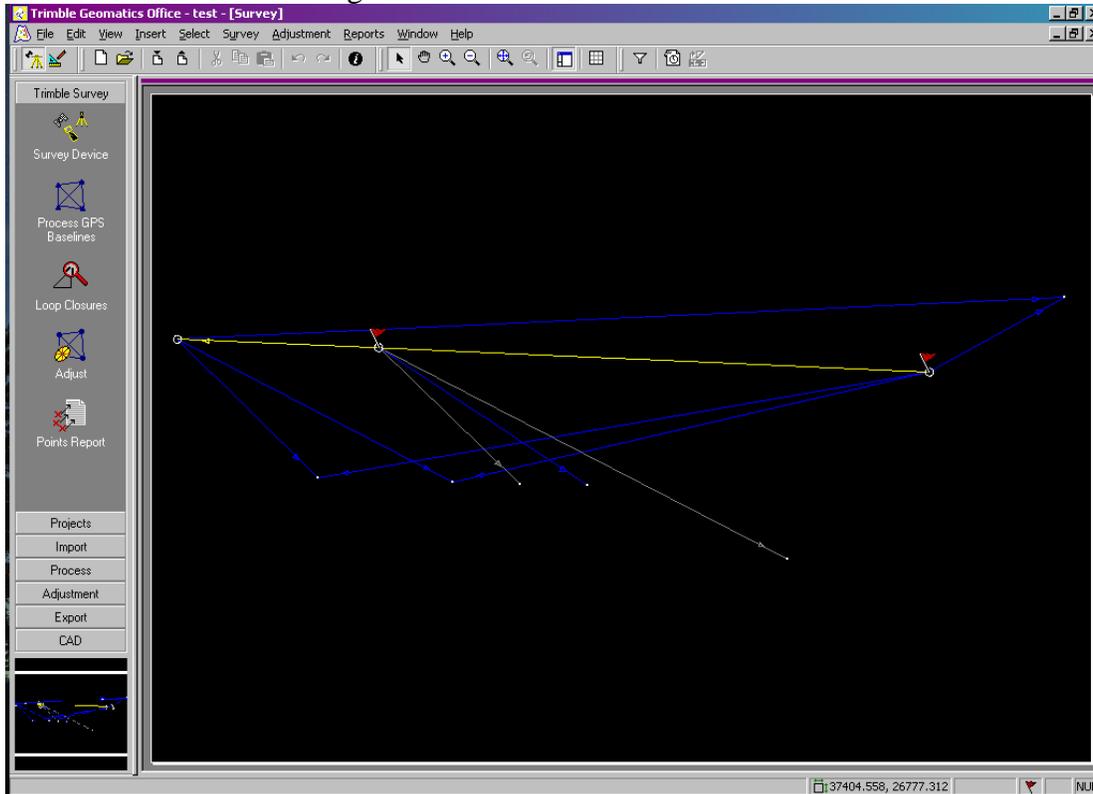
After trying to reprocess, errors kept coming up that "insufficient data for OTF processing". These three points will have to be re-observed.

If the three control points (base stations) used in the example would have had known XYZ coordinates and keyed into the dc before any surveying was done, we would be done and you could export the ascii files.

But, you will also note that two points were "flagged" as low quality starting points. All this means is that these base station coordinates were not keyed in or fixed points. The "here" key was used to start the position for these points. We can adjust the coordinates to "fix" these locations. We can enter the XYZ coordinates we get from OPUS to translate the positions of these base stations, which in turn, translates all points observed from them. Fix only one to begin with so you can see how well the other matches the OPUS solution coordinates. Begin by entering the "True" coordinate values for point "H510".

First we need to load the "Geoid" model. Select "Adjustment" – "Observations" – then the "Geoid" tab. Hit the tab "Load" to get the window below.

Observations

GPS | Terrestrial | Geoid

Load | Unload

OK | Cancel | Filter...

Observations:

Use	Obs	Point	Separation	Error	Variance Group	Std Res
☑	N/A	H13	-58.6498	0.1063	\<Geoid Default\>	?
☑	N/A	3012	-58.6943	0.1063	\<Geoid Default\>	?
☑	N/A	3013	-58.6470	0.1063	\<Geoid Default\>	?
☑	N/A	3014	-58.6470	0.1063	\<Geoid Default\>	?
☑	N/A	3015	-58.6470	0.1063	\<Geoid Default\>	?
☑	N/A	H510	-58.8718	0.1063	\<Geoid Default\>	?
☑	N/A	525	-58.9277	0.1063	\<Geoid Default\>	?
☑	N/A	526	-58.9277	0.1063	\<Geoid Default\>	?
☑	N/A	H3712	-58.7125	0.1063	\<Geoid Default\>	?
☑	N/A	3006	-58.7384	0.1063	\<Geoid Default\>	?
☑	N/A	3007	-58.7384	0.1063	\<Geoid Default\>	?

Now we can adjust the coordinates and elevations. Select "Adjustment" – "Points".

Points

Points: Adjustment Datum: WGS-84

OK | Cancel

Point	Northing	Easting	Height	Elev	Fixed
H13	364937.3572	1409115.8252	2132.5741	2191.223	
3012	359345.0015	1419885.0167	2169.4055	2228.099	
3013	359494.9149	1414605.8751	2209.7533	2268.400	
3014	359494.7127	1414606.7711	2210.0194	2268.666	
3015	359494.6628	1414606.8447	2210.1631	2268.809	
H510	363648.7821	1438527.5643	2028.2112	2087.082	
525	366576.3339	1443843.3208	1894.2358	1953.163	
526	366576.3914	1443843.3275	1894.1762	1953.103	
H3712	364612.2902	1416987.0472	2136.8661	2195.578	
3006	359209.0695	1425165.2743	2080.2221	2138.960	
3007	359208.5722	1425165.2238	2080.2446	2138.982	

Fix
☐ 2D
☐ Height
☐ Elev.

○ Grid   ○ Local   ○ WGS-84

Once the correct Northing Easting and Elevation are entered, notice the check marks in the Fix column. Hit OK to adjust. The "Recompute Needed" balloon will appear in the lower right hand corner of the TGO window. You MUST double click this balloon to re-process the data. In fact, if you ever see that balloon, it is a good idea to double click it to make the changes.

Now lets compare a known point with what we get with the adjustment. Keep in mind, these control points are 29444.887' apart, over 5.5 miles.

OPUS position H13	TGO adjusted	Error	
364932.3917	364932.3679	0.0238	
1409121.2139	1409121.1797	0.0342	
2186.5289	2188.148	1.6191	OUCH!!!!!

What happened with the elevation? After a *severe beating* of the field crew, We find out that the rod height of H13 was not really 5.125 as the checkin showed. It was really 6.562 and the "measured to" had to be changed also.
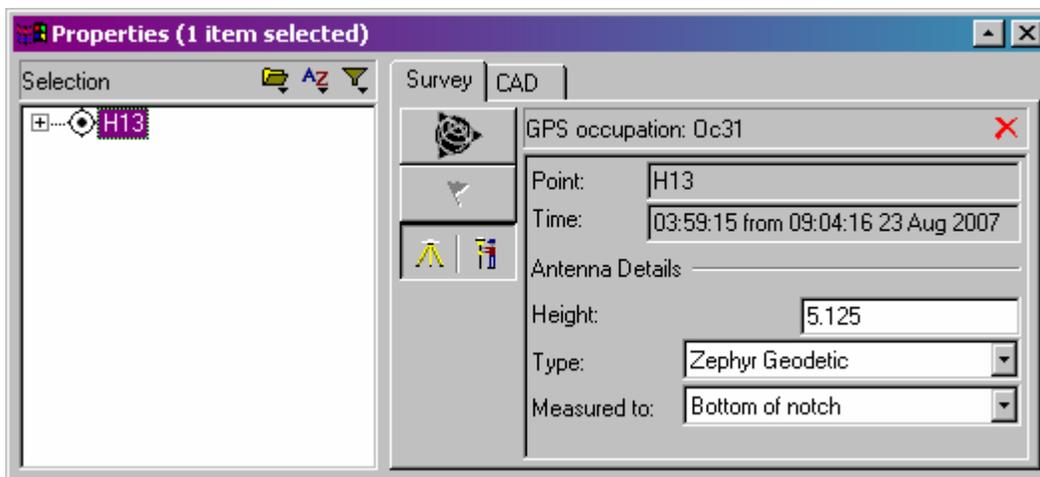
To fix this, highlight the point in question and change the metadata (Height and Measured to) as shown.
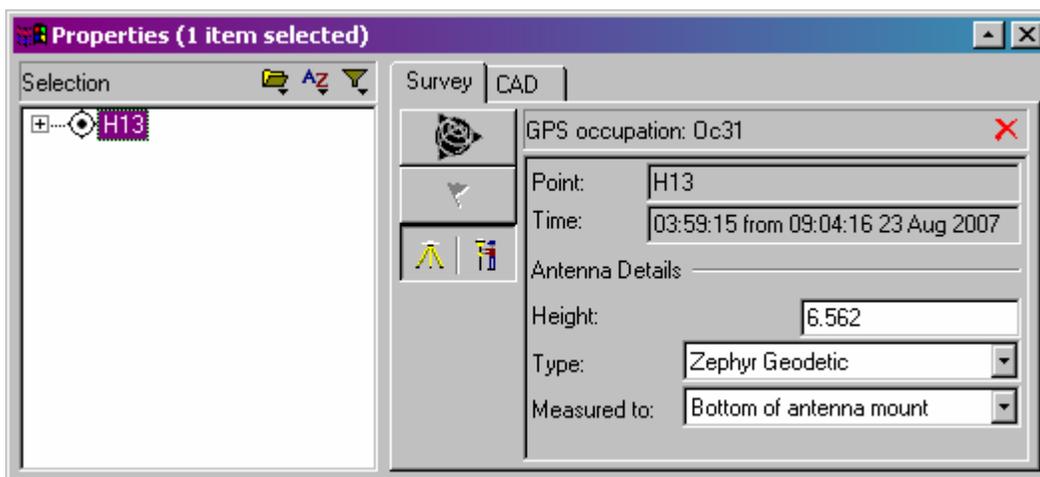
This will require double clicking the "Recompute Needed" balloon.

Point	Northing	Easting	Height	Elev	Fixed
H510	363643.7926	1438532.9232	2025.1442	2084.015	NEe
H13	364932.3679	1409121.1797	2127.8860	2186.535	
3012	359340.0113	1419890.3728	2166.3348	2225.028	
3013	359489.9248	1414611.2304	2206.6811	2265.327	
3014	359489.7226	1414612.1264	2206.9473	2265.594	
3015	359489.6727	1414612.2001	2207.0909	2265.737	
525	366571.3448	1443848.6805	1891.1694	1950.096	
526	366571.4023	1443848.6872	1891.1098	1950.037	
H3712	364612.2902	1416987.0472	2136.8661	2195.578	
3006	359209.0695	1425165.2743	2080.2221	2138.960	
3007	359208.5722	1425165.2238	2080.2446	2138.982	

Points — Adjustment Datum: WGS-84

Fix: ☑ 2D ☐ Height ☑ Elev.

◉ Grid ○ Local ○ WGS-84

Lets see how they match after the error was corrected.

OPUS position H13	TGO adjusted	Error	
364932.3917	364932.3679	0.0238	
1409121.2139	1409121.1797	0.0342	
2186.5289	2186.535	0.0061	Much better

Now maybe you can see the importance of "Field Notes" and communication between the field crew and the computer processor. With results like this, I feel comfortable with fixing H13 coordinates to the OPUS solution values and not warping the side shot values.

One last problem with this survey is that observations were also taken from H3712 as the base station. Unfortunately, no baselines from other known points were created during this survey to this control point. So basically it is a "stand alone" survey with absolutely no redundancy. So we will have to "Fix" this point also and re-compute one more time for the final answers.

Point	Northing	Easting	Height	Elev	Fixed
H13	364932.3917	1409121.2139	2127.8794	2186.528	NEe
H510	363643.7926	1438532.9232	2025.1442	2084.015	NEe
H3712	364608.2447	1416992.0440	2134.4406	2193.152	NEe
3012	359340.0023	1419890.3793	2166.3421	2225.036	
3013	359489.9578	1414611.2664	2206.7568	2265.403	
3014	359489.7452	1414612.1374	2206.9655	2265.612	
3015	359489.6953	1414612.2250	2207.1621	2265.808	
525	366571.4062	1443848.7480	1891.2326	1950.160	
526	366571.4261	1443848.7214	1891.1032	1950.030	
3006	359205.0234	1425170.2722	2077.7996	2136.537	
3007	359204.5261	1425170.2216	2077.8221	2136.560	

Adjustment Datum: WGS-84

Fix: ☑ 2D ☐ Height ☑ Elev.

◉ Grid ○ Local ○ WGS-84

Now if I import the dc file, the coordinates will adjust to the fixed points above. If I were to import the dc file first, or if I were to delete the adjustments above, I would have to fix the coordinates of the control point as before.

Creating a Micro-Station drawing from an ASCII text file.

The first thing that has to be decided is, where the data is to reside. In order for the entire DOT to have access, the official project directory is the best option. All districts and central office personnel have access to the "R:\" drive. Within the "R:\" drive is the project directory folder where all projects that have assigned numbers are stored. They are sorted by "District_Hwy_MilePoint.Agreement number" for example, the project "SS-8-011(015)166" is a survey on Hwy 11 from Hankinson to I-29. The project folder is "80011166.015" Under that project directory, are several sub-folders that are created when the project is created. An option is the "district" folder as shown below.
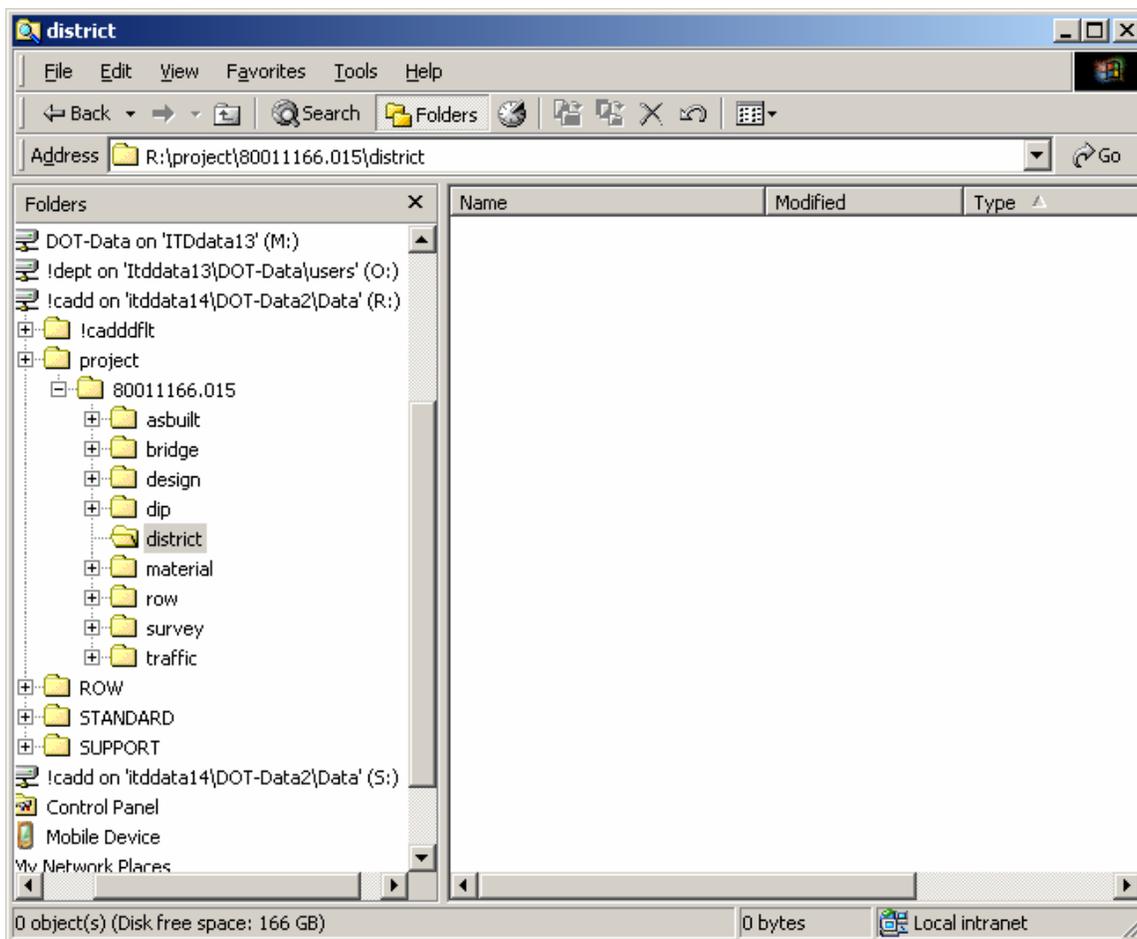
Only district's have writing rights within that folder. All others can only read or copy from that folder. You can create as many sub-folders under the "district" folder as needed. There should however be some sort of standard to follow so everyone can understand and be able to find the information they are looking for.

In the "Surveys and Photogrammetry" section of design, we have writing access only to the "survey" folder, so the example from hereon will be within that folder.

As you can see below, we create sub-folders to store certain information in. First and foremost, is the "Aareadme.doc" word document. We use this word document as sort of a diary for the project. We store information about the projects purpose, limits, history, contact engineers, scale of drawings, how alignments are created, what is contained in the other sub-folders etc. These word documents come in very handy when revisiting the project several years later.

In this case, you see a "Compilation" folder. This folder is where all the information for the aerial stereo plotter data can be found.

The "Photo_scans" folder is where we store Highway plans, Right of Way plats, (scanned) Sign Inventory sheets and photograph .jpg's etc.

The "EFB" folder is where we store all the "Electronic Field Book" data and drawings created from them. The CADD editors will copy those drawings into the final "survey" drawings to be used by the design engineers.
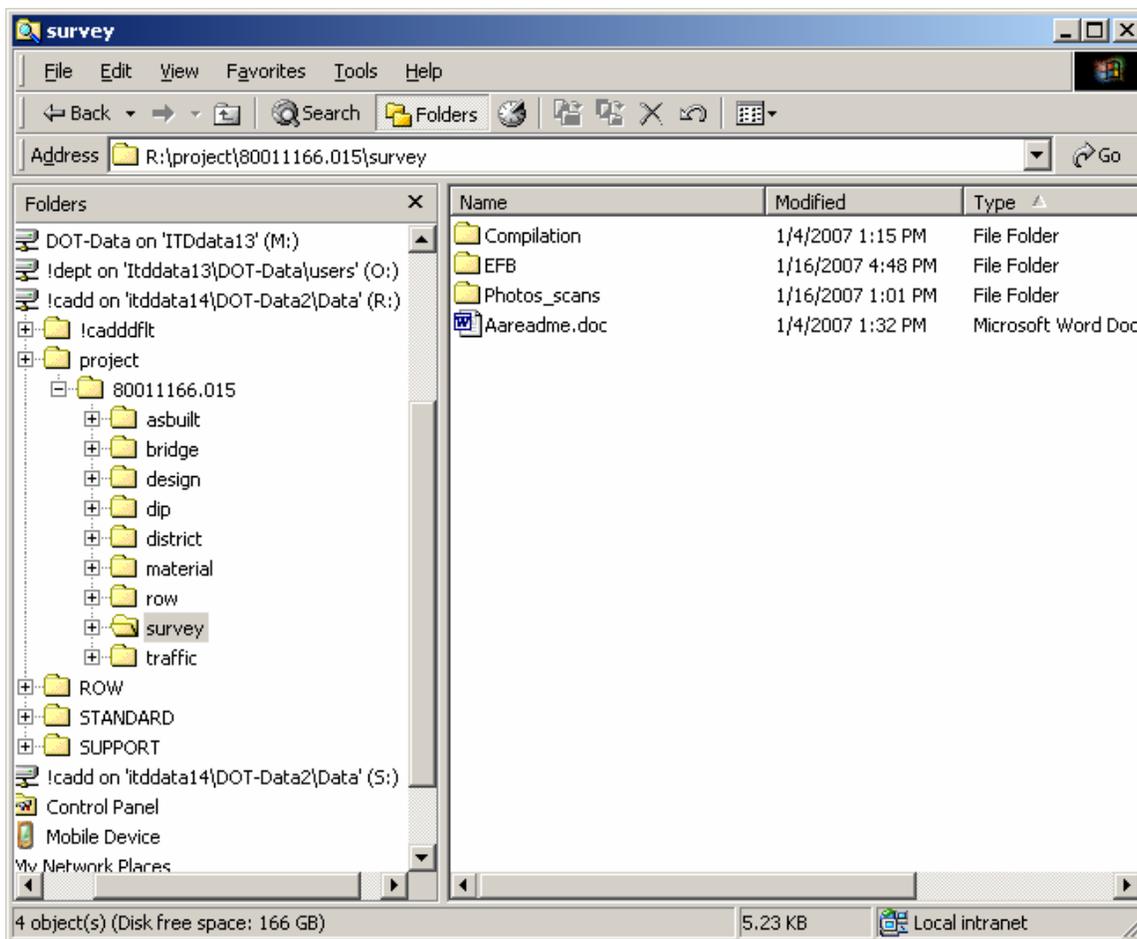
Within the "EFB" folder shown below, we create additional sub-folders as needed. The "GPS Data" folder contains the Trimble Geomatics Office (TGO) information, including all the data collector (.dc) files. The "Ascii" folder contains all the ascii text files (in ground coordinates) created in TGO needed to import into Micro-Station drawings.
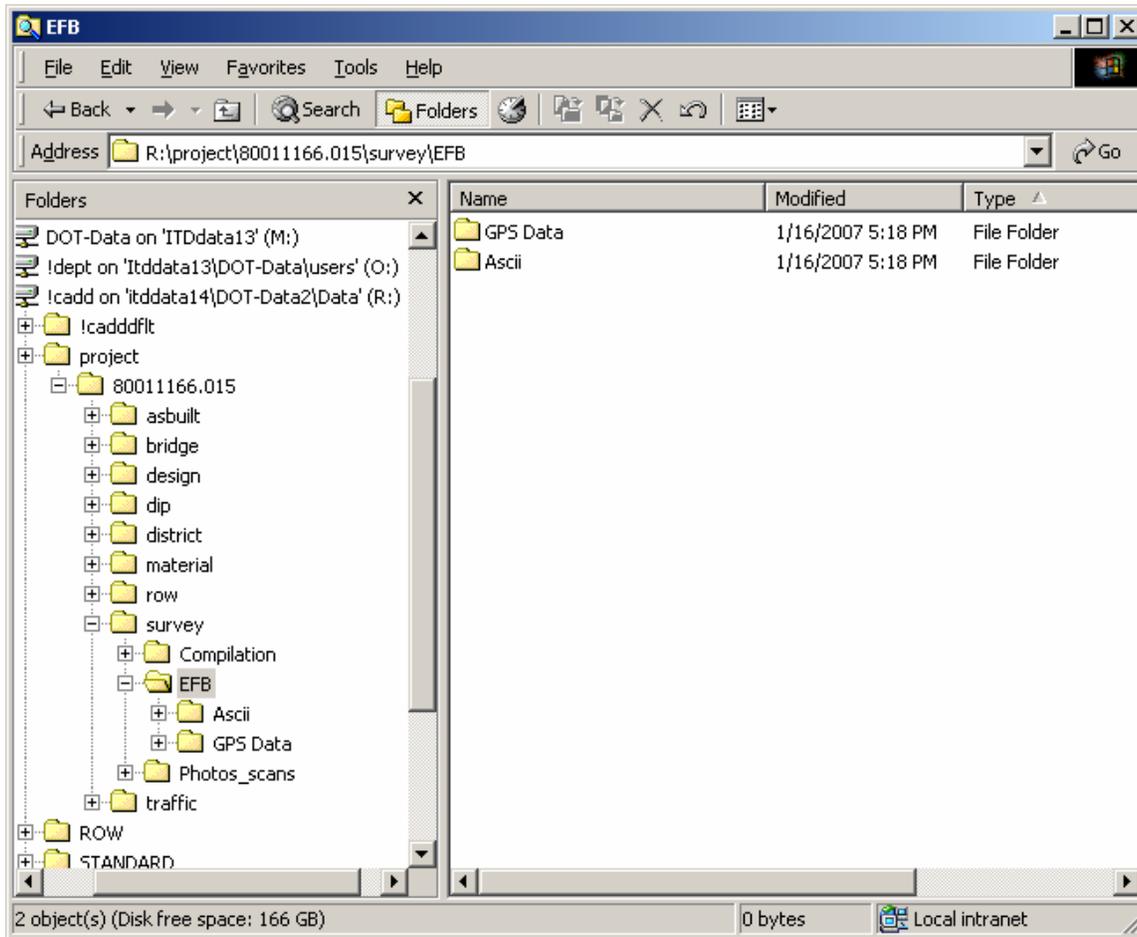
Under the Ascii folder is the "Hankinson2.txt" file. It is imperative that the format of this ascii file is correct. "Micro-Station / Geopak" (MS/G) will only read data if it is presented correctly. There are many ways MS/G will import data files, but to be consistent we prefer "comma delimited" files, in ***ground coordinates***.
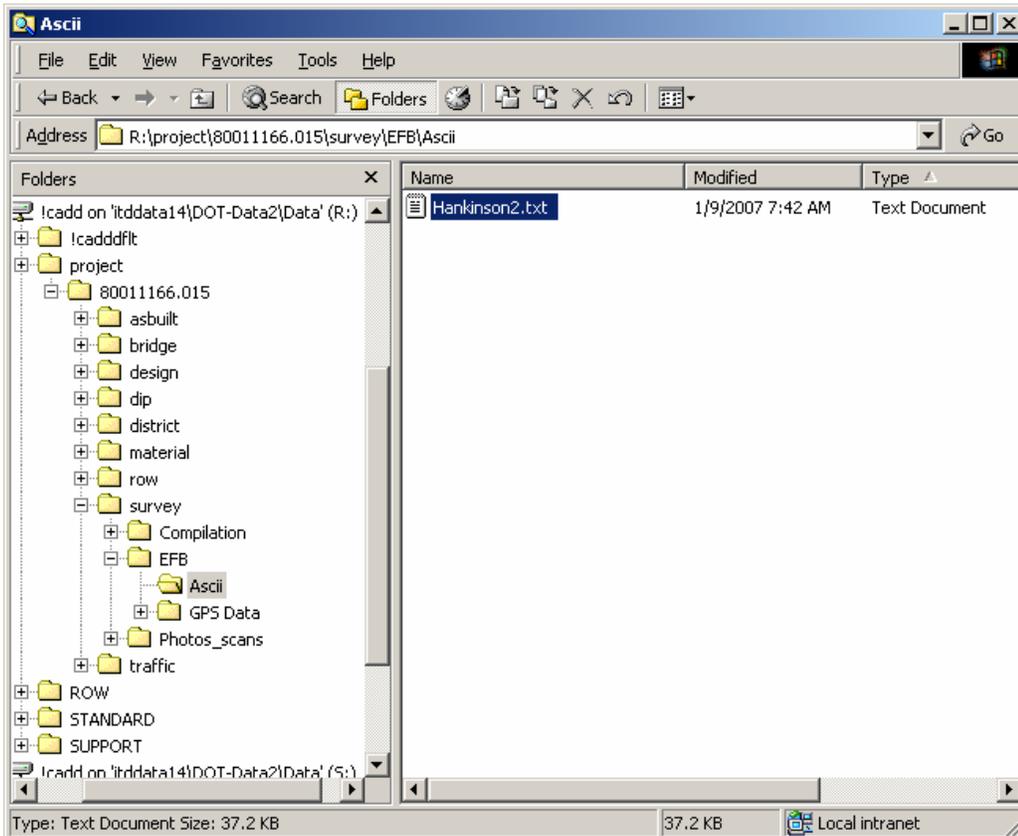
Here is a small sample of what is in the ascii file. Headers in the ascii text file are a good way to know what you are looking at and do not interfere with the importing of the data.

Hankinson2.txt
Ground Coordinates
SS-8-011(015)166
Hankinson to I-29
Richland County
1/CF= 1.0000655043
1/9/2007

1, 166861.4384, 2886956.7527, 1062.0370, GPS1* GPS11-1
2, 162138.2121, 2899144.4810, 1065.7020, GPS2 *GPS11-2
500, 162138.2037, 2899144.4605, 1065.7391, CHK2
501, 162348.2037, 2899164.4265, 1068.7491, +TFO *QWEST
502, 162398.5683, 2899172.5679, 1069.5676, TFO

Point number, Northing, Easting, Elevation, Code *Description

Open "MC/G" and create a 3D drawing in the appropriate directory. In this case, all the drawings will be placed under the EFB folder. The name of this drawing "EFB-Topog" which represents that this drawing is of topography created by electronic field book data. Be sure the "Seed File" is correctly selected to be a 3D type drawing.
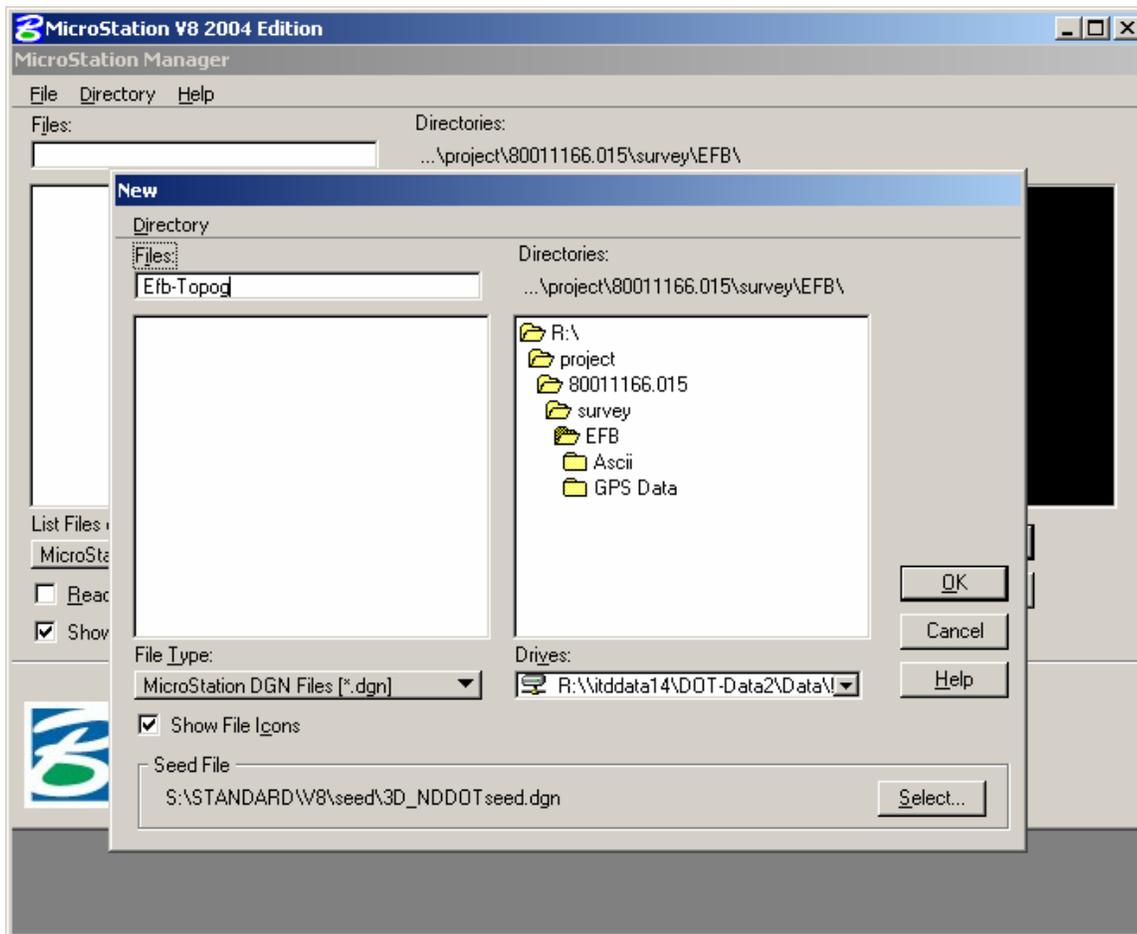
Once your MC/G drawing is open, select Applications - GEOPAK– Activate GEOPAK.
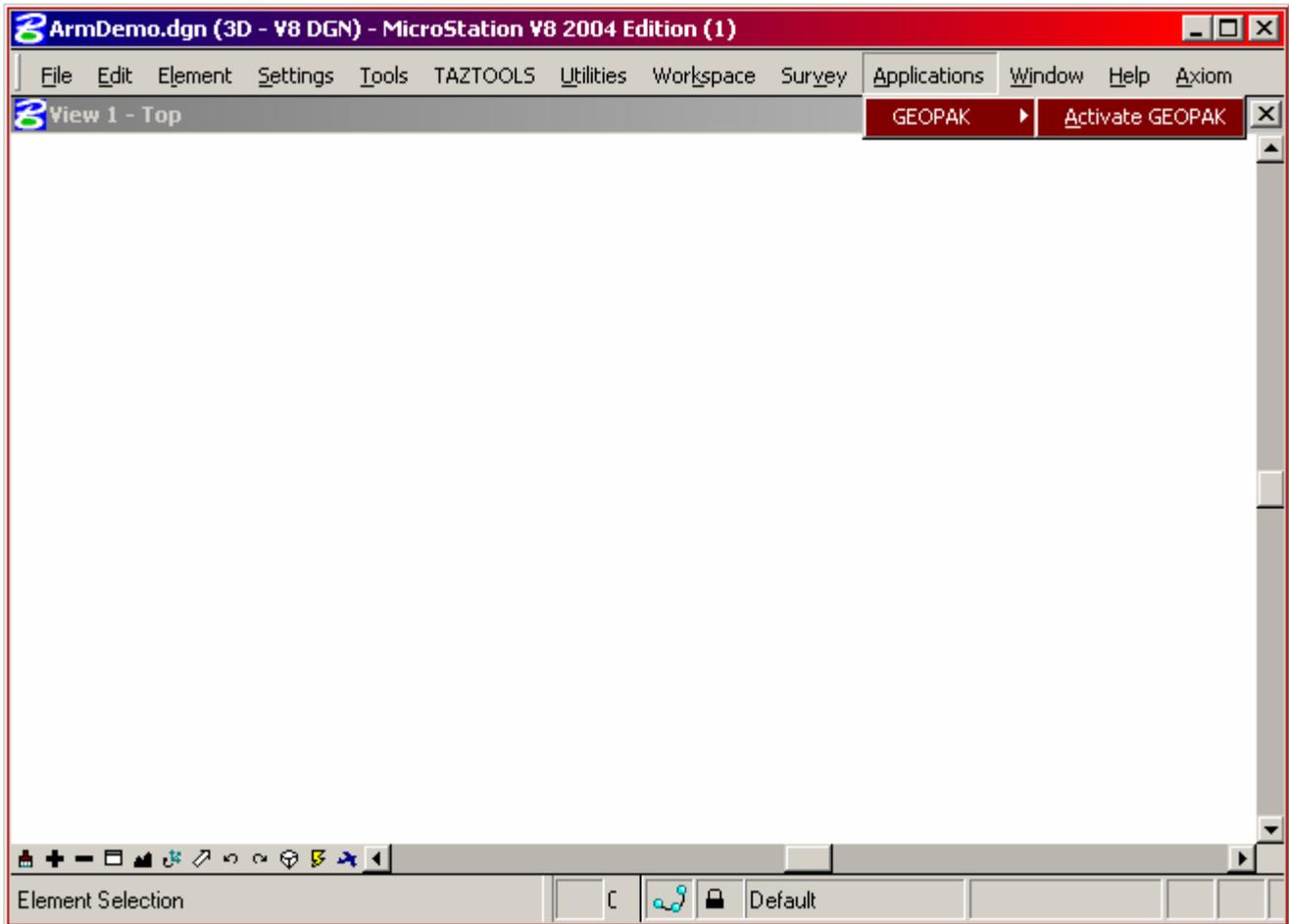
Then again select Applications – GEOPAK SURVEY – Survey.
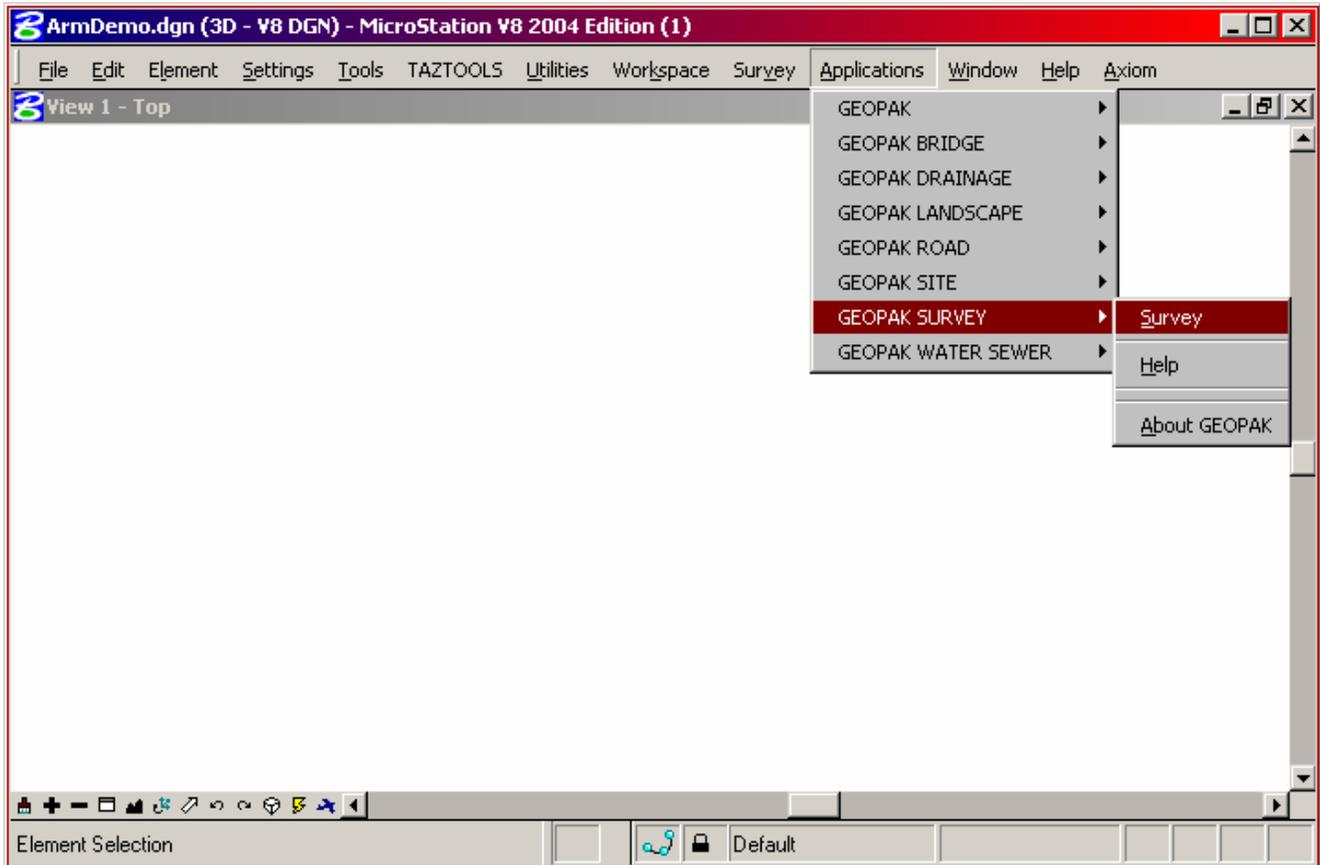
Now its time to create a project in "MS/G". To do this select "Survey – Project – New"
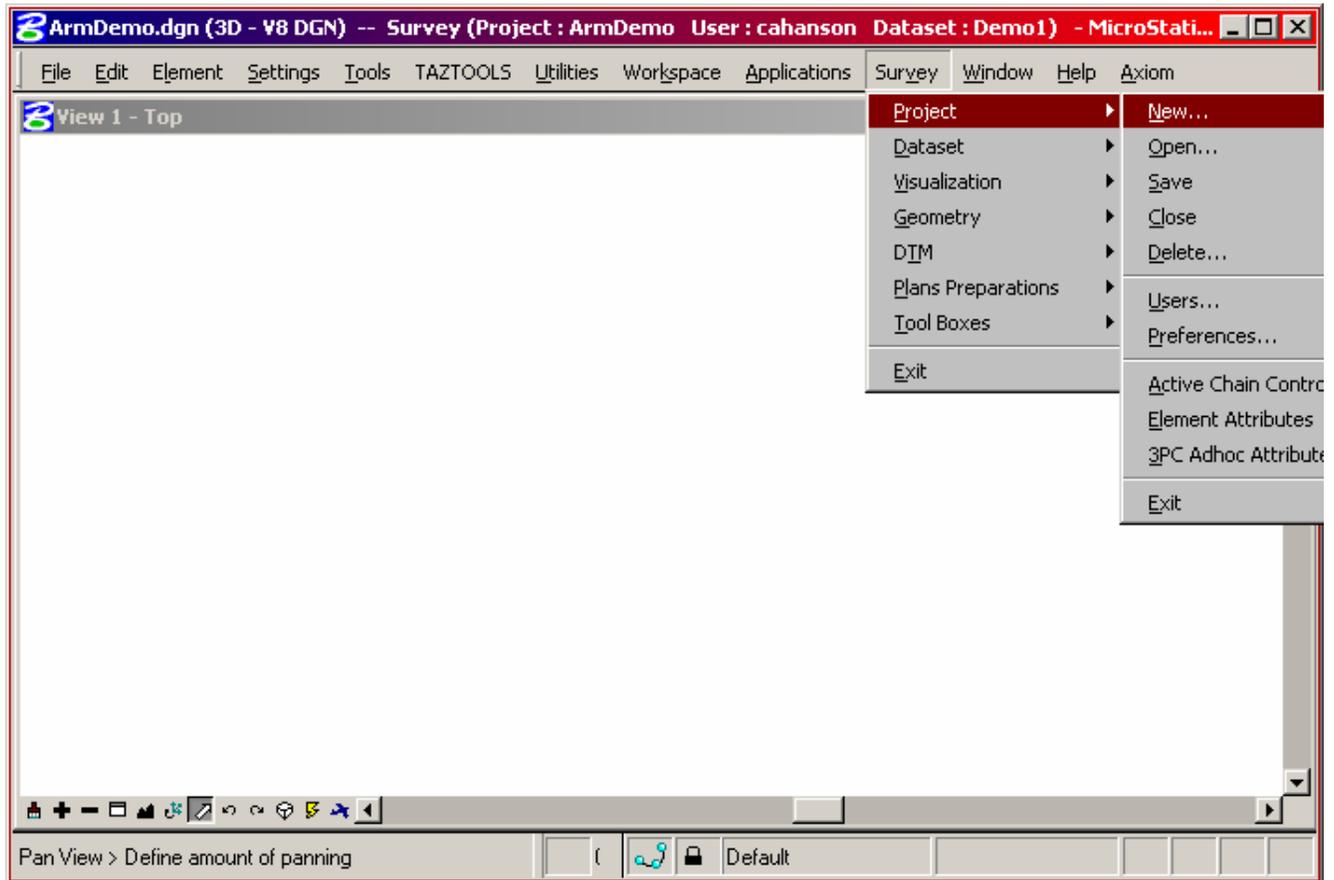
Enter an appropriate project name, Job number and Description.
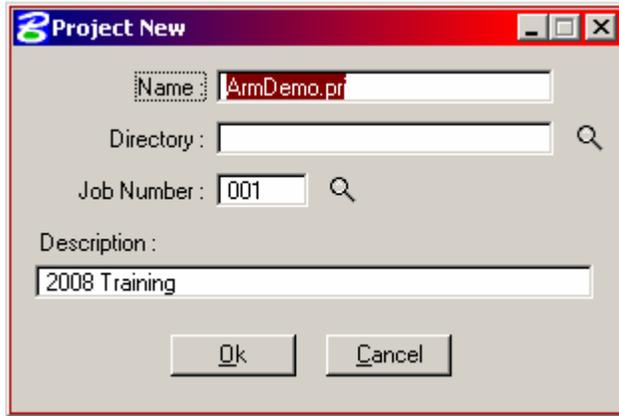
Now we must make sure the project preferences are set up correctly.
Select "Sur<u>v</u>ey – <u>P</u>roject – <u>P</u>references"
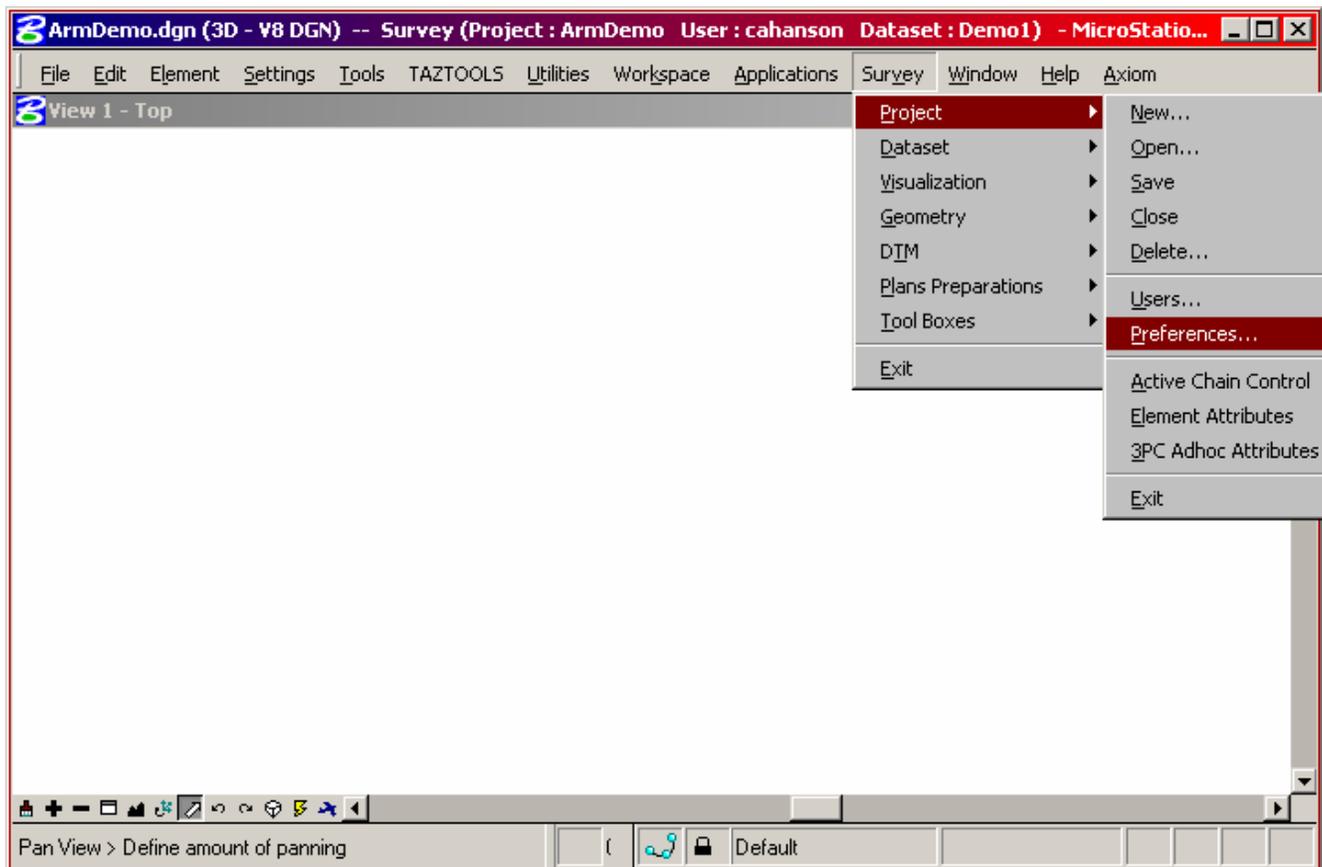
Each tab shown has a window (on the left side) of other options. Shown below, the "Project" tab has three additional settings to check. Most of the settings for all the tabs will be set by default, once you have completed this task the first time and saved it as a default.

Usually, the "Settings" option is completed when you create the project.
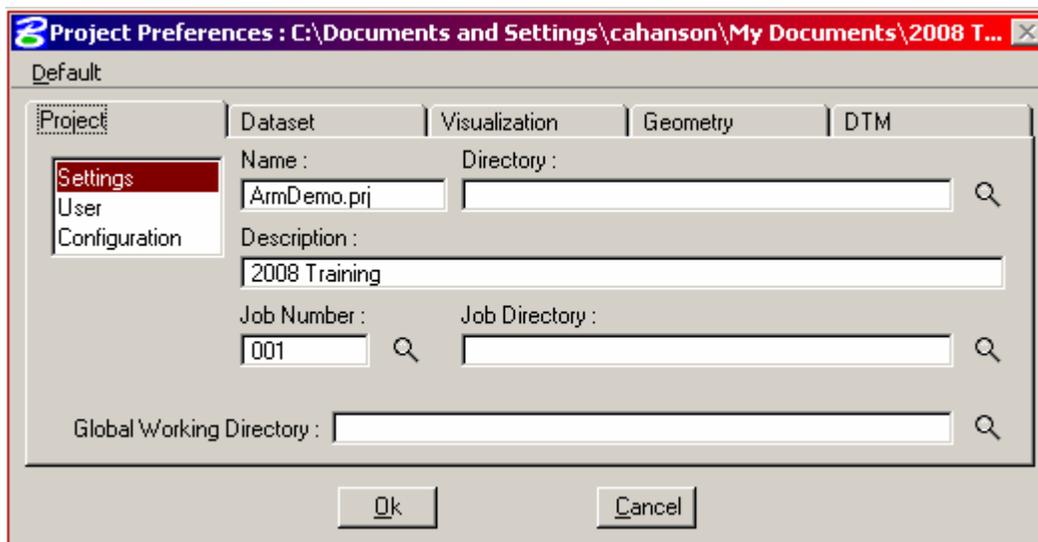
The "User" option can be filled in with your user name, then full name. Most importantly, the "OP Code" (operator code) must be set to "nd".
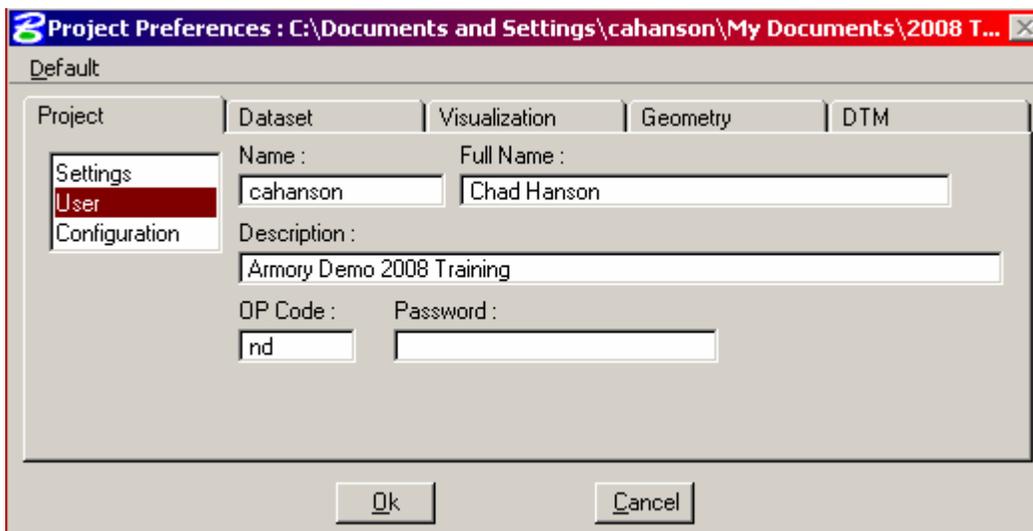
The "Configuration" option is a personal preference.
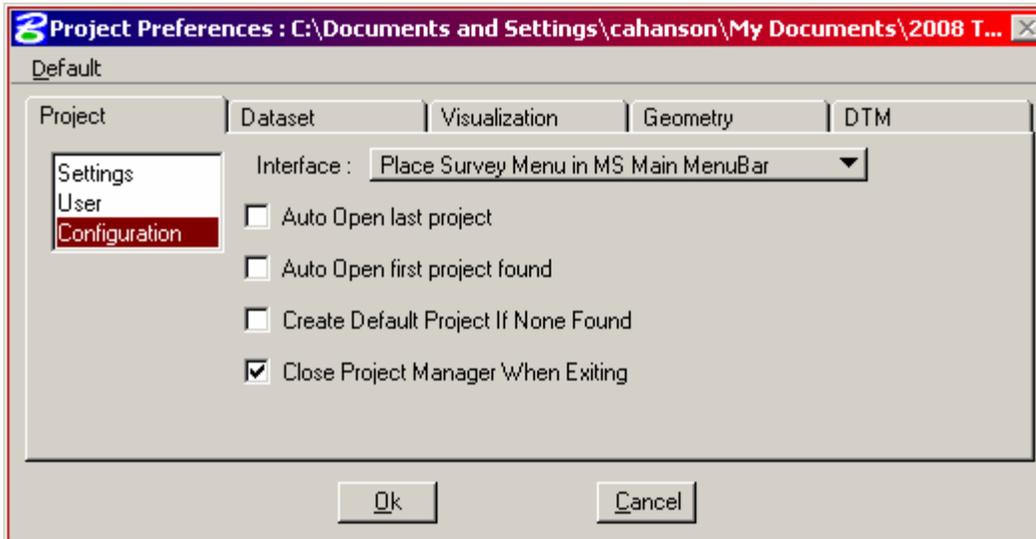
You should experiment with all the options to find what suits you best.

The "Dataset" tab.   The most important of these options are the "Data Source" and "Linking Codes".
The Data Source needs to be set to "ASCII File(s)" and the ASCII Type set to "XYZ to Coordinates".
Also check the box "Process LcodePcode same as Raw Data"
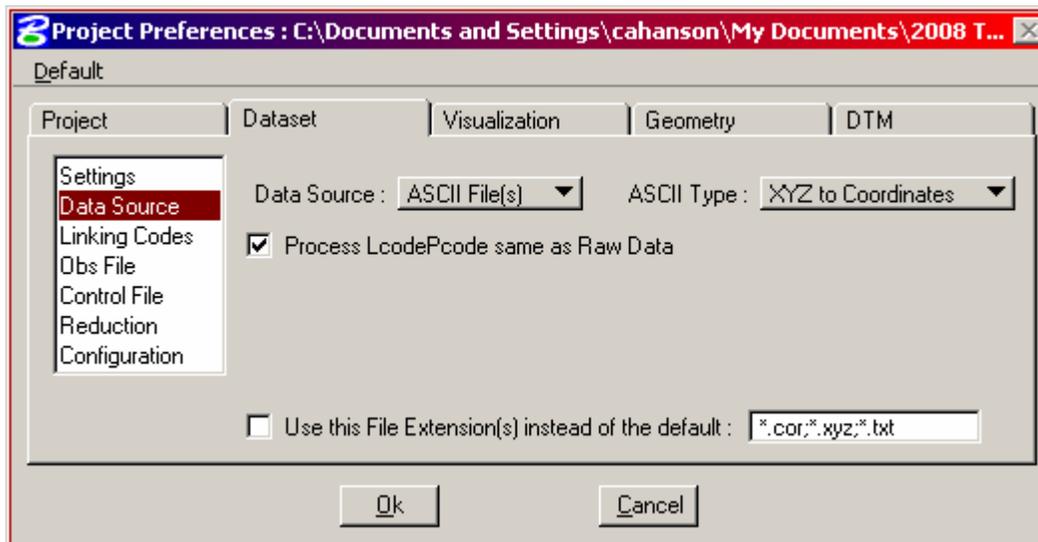
The Linking Codes should be set as shown below.
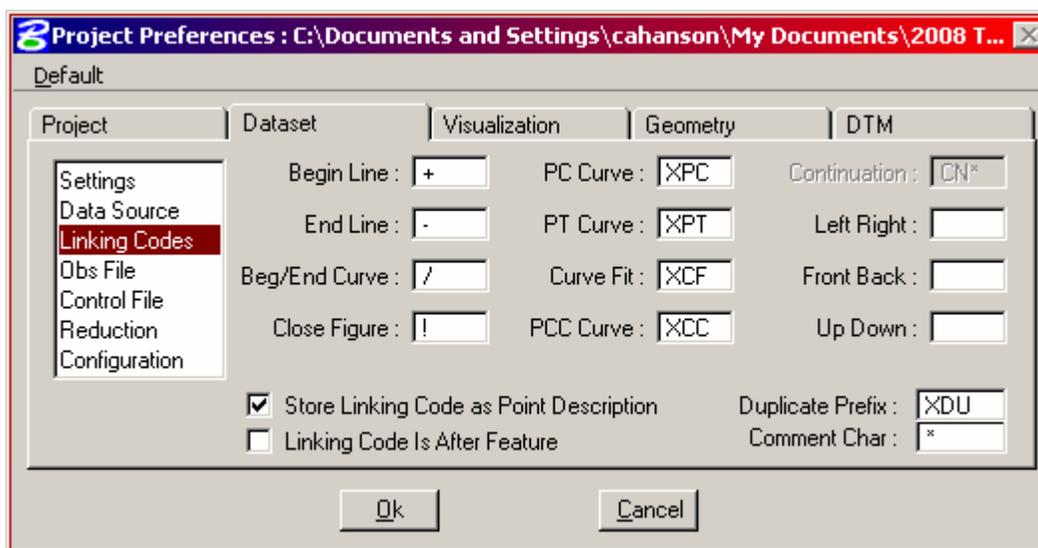
Next Tab is "Visualization", the most important is the "SMD Feature File:" Set this as shown. The plot scale is determined by urban (40) or rural (200) project location. Always check "Apply Feature Best Match".
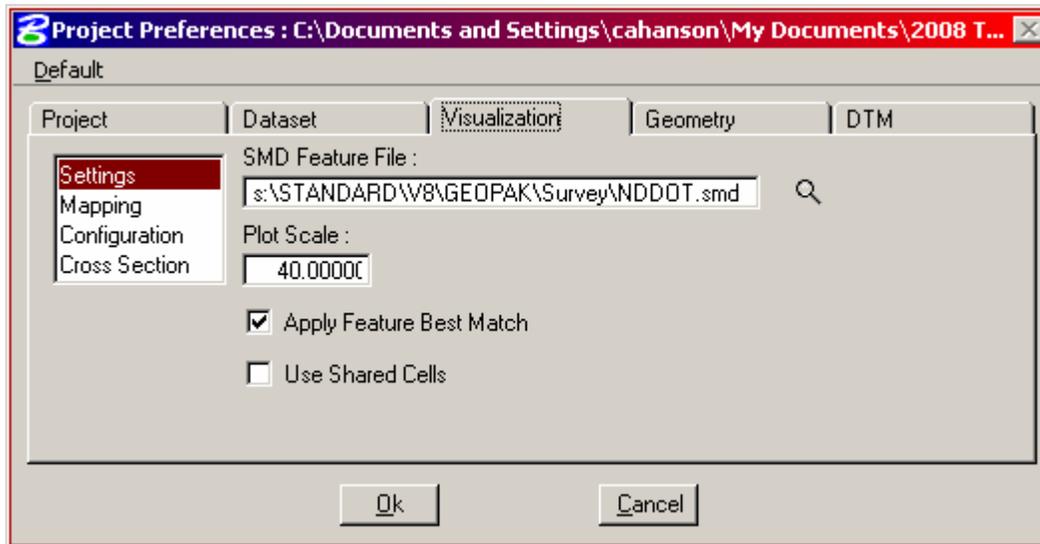
In the Mapping option, check all that are shown
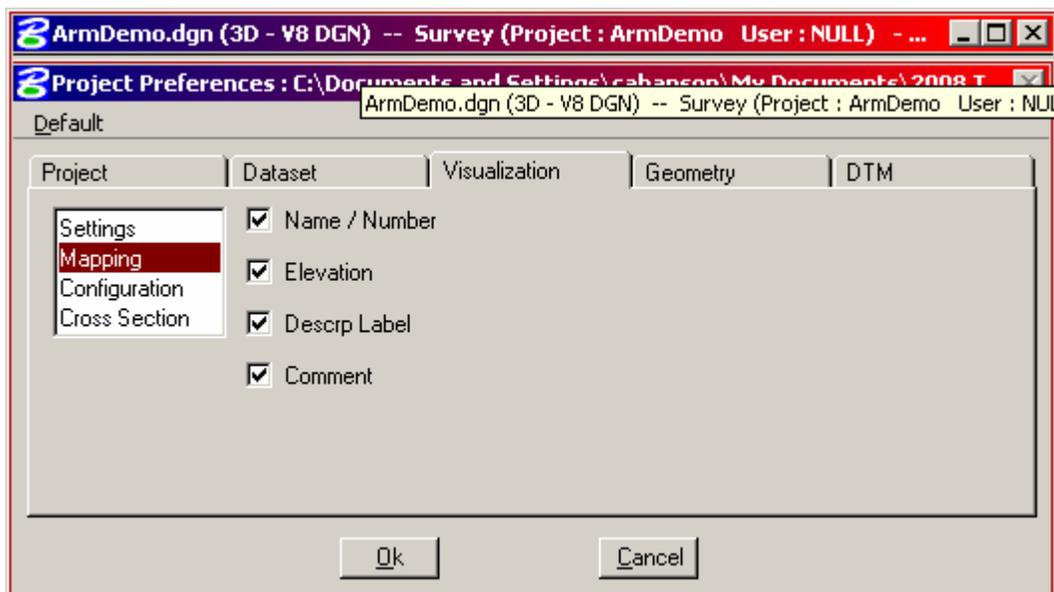
In the Configuration option check Auto Draw Mapping After Process or Import, and set the "Point Label Re-Mapping" to Redraw according to SMD.
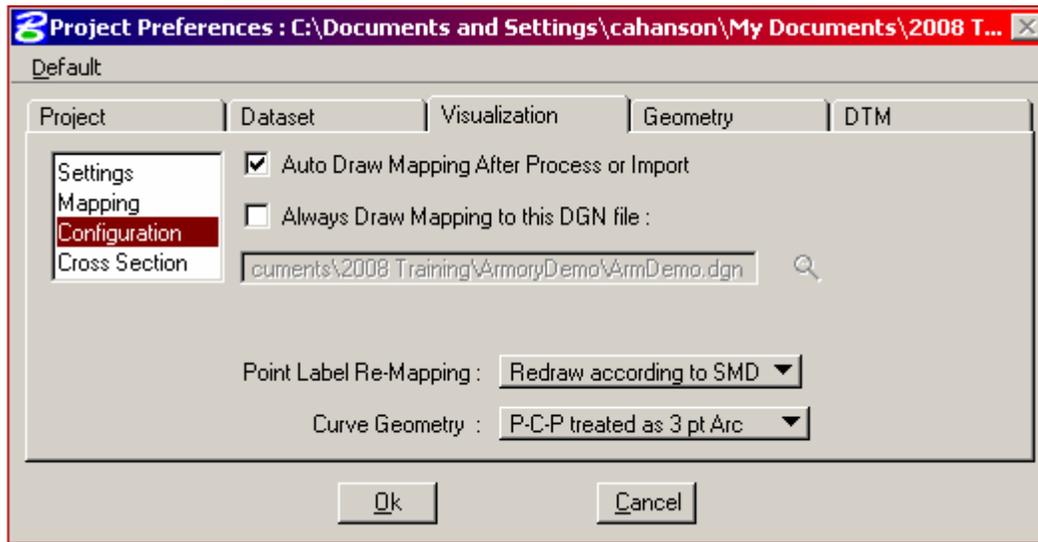
The Geometry and DTM tabs, generally the default is sufficient. All settings in the Project Preferences can be adjusted to your own personal needs, so go ahead and play with the settings. Once you like all the settings save it as a default, then only job specific items will have to be entered when creating new projects.

Now we are getting close to importing data. For every import, we need to create a new "Dataset".
Select Survey–Dataset–New.
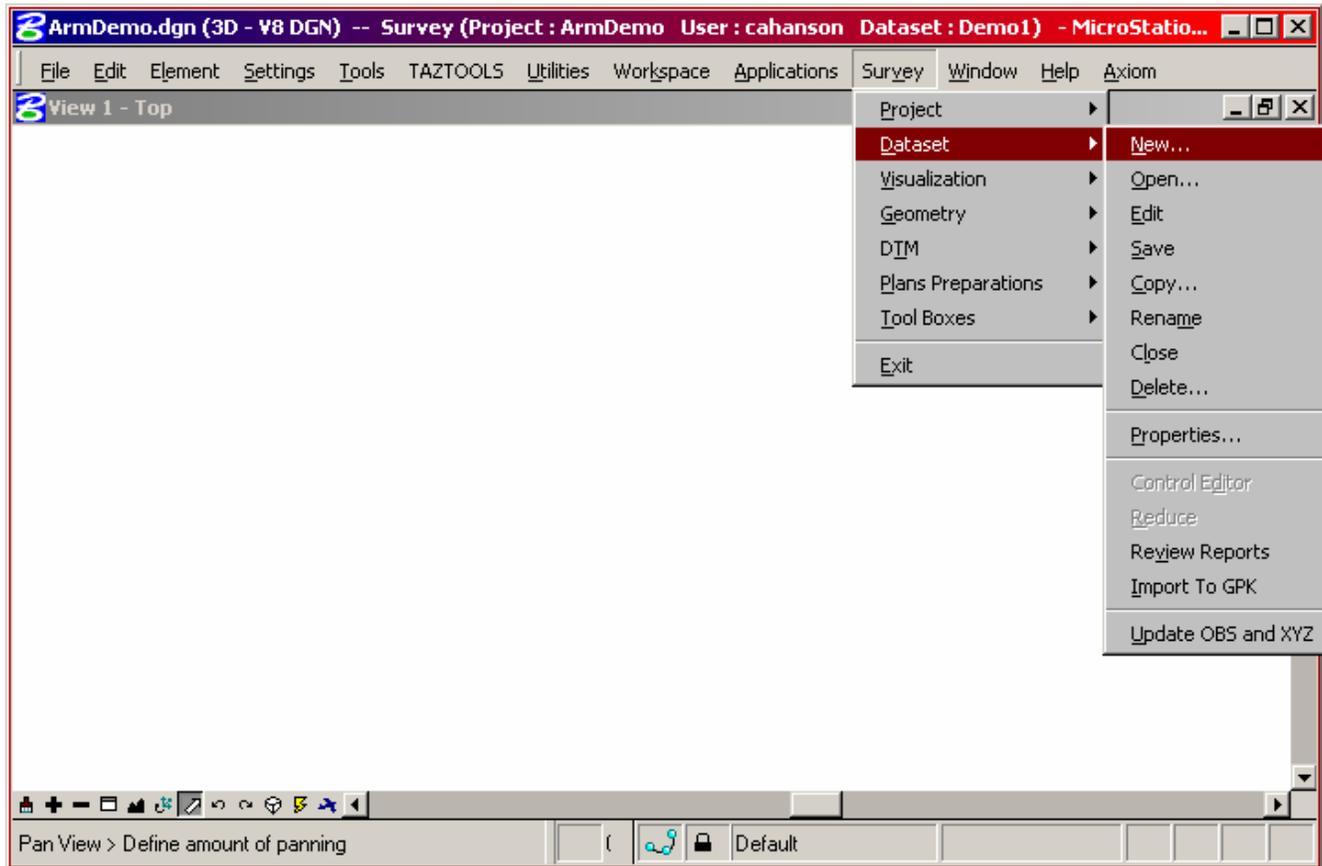
The name of the dataset should be a logical one that you can remember. Then select the "Source Format" by clicking the top icon [to the right of "File(s) to Use:"] and navigate to the ascii file you want to import.

Use the button to select the asii file you are to use.
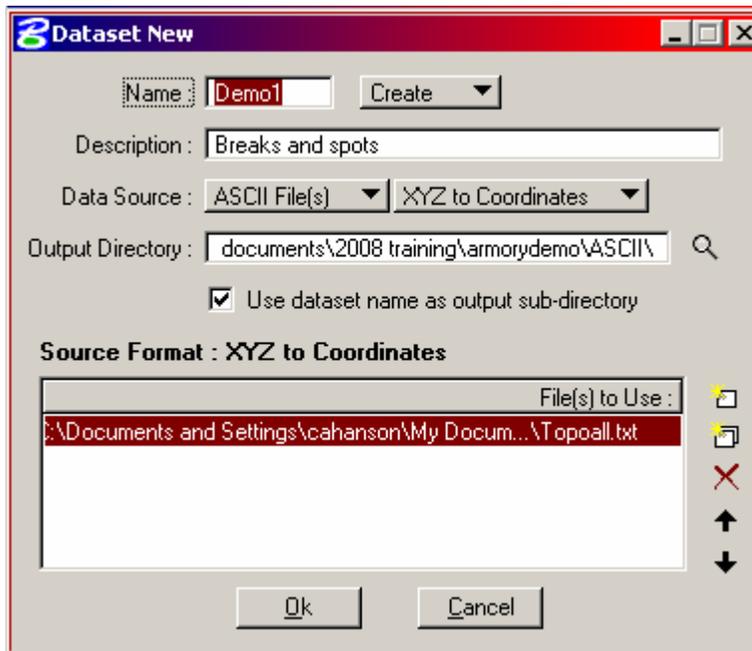
This will open up the import file in the following screen. Highlight the first line of ascii data. This will show up above the tabs. Populate each tab with the correct value as shown below.
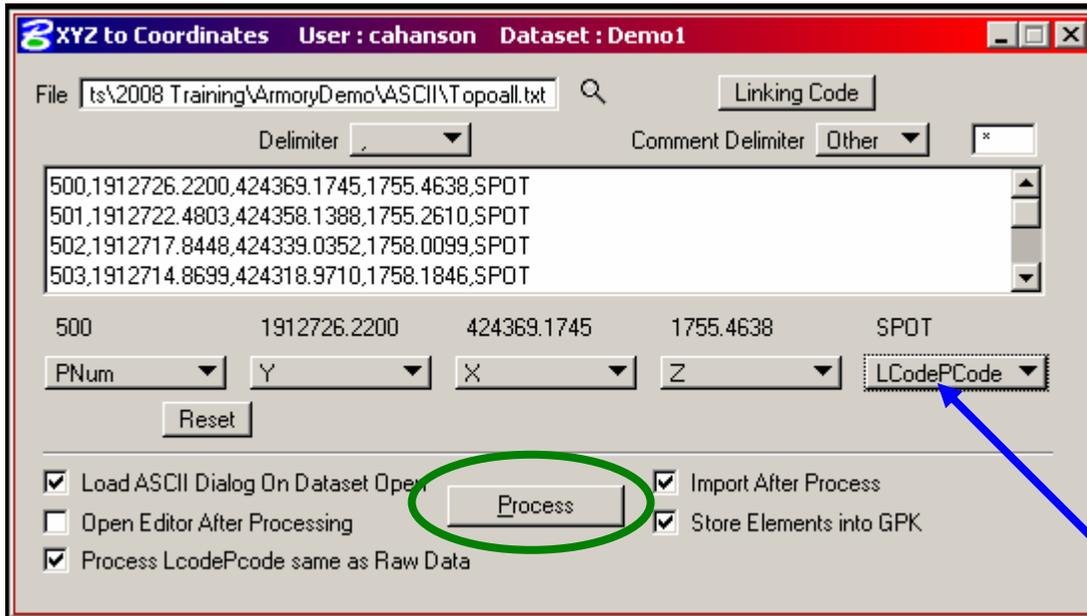
Once this is done, select the **Process** button.

Select the fit view on "MS/G" and the drawing should appear.
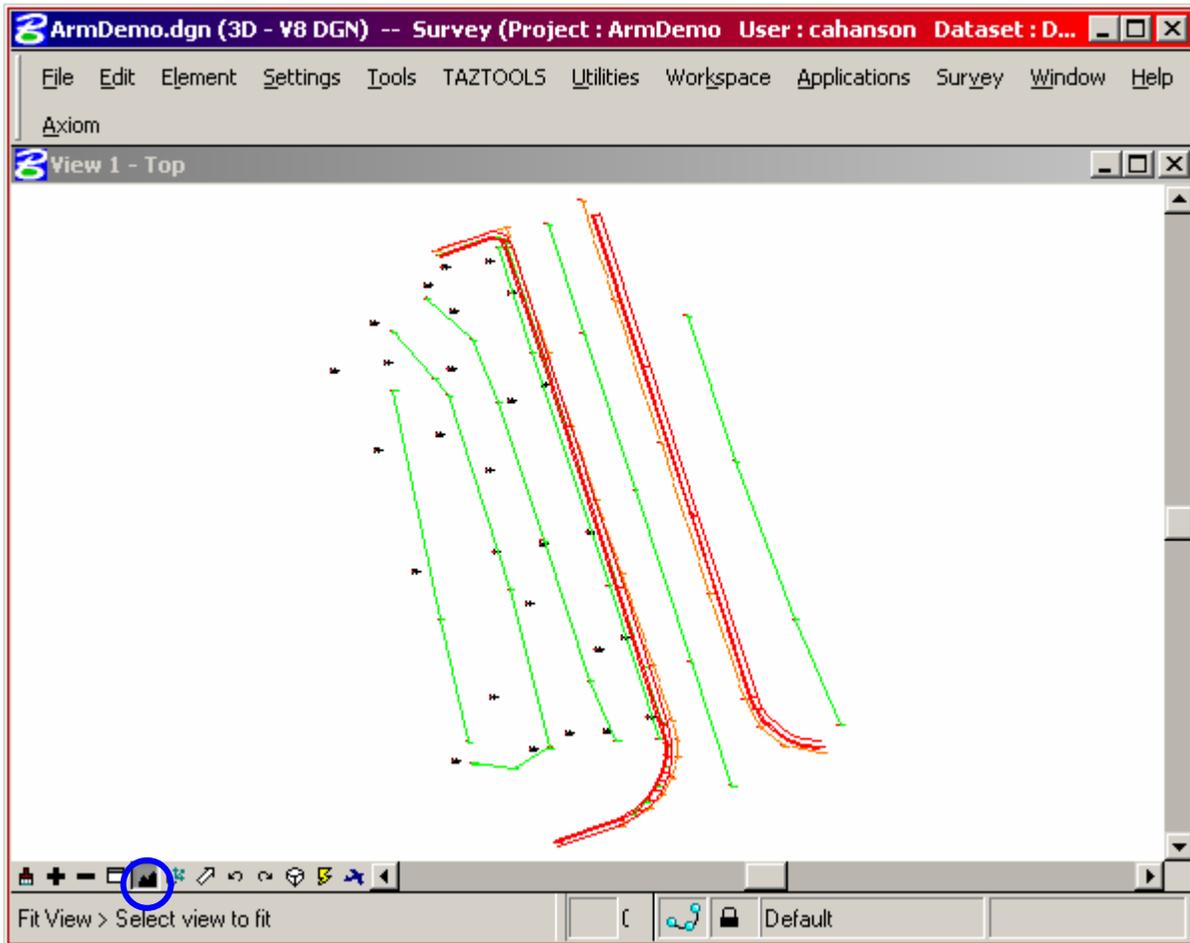
The first thing to check is the coordinate locations and elevations. Select a single point and match it up with the ascii text file to be sure the XYZ value is correct. Rotate the view to the front or side to see if all points are within reason of difference in elevations.