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# Data Point Intelligence, Construction Stakeout and DTM Points (Nodes and 3D Faces)



The proper name for DTM elements are Nodes and 3D Faces. Database COGO points and DTM Nodes are not the same thing.

The need for data point intelligence differs based on the use of the data. In the Machine Control environment, DTM Nodes and 3D Faces are often misunderstood to be points that are suitable for construction point stakeout. While there are common elements to DTM Nodes and construction stakeout points, there are also significant differences. This discussion will address the differences between the two.

## Comparison of DTM Node Graphics and Stakeout Points Graphics

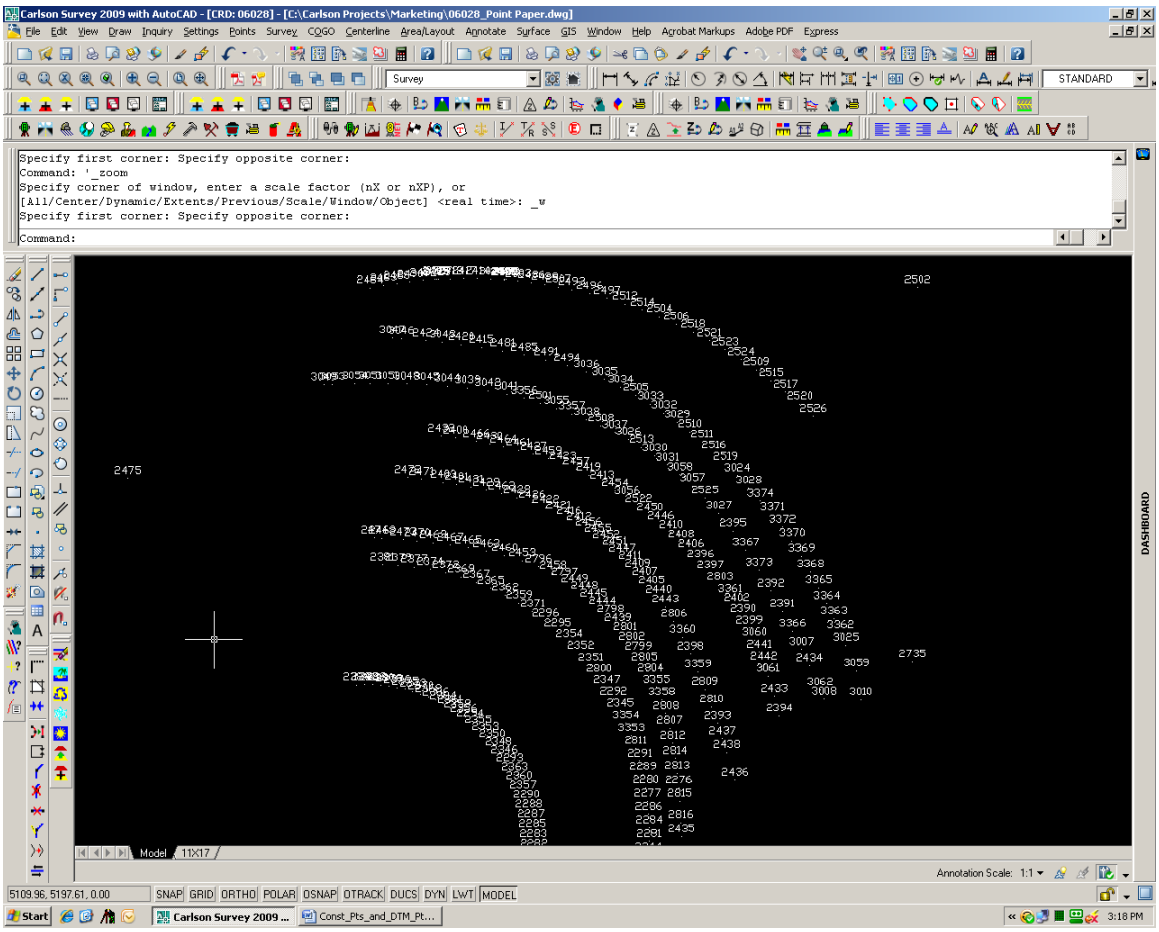

Figure 1

Figure 1 is a plot of DTM Nodes. There are several significant issues of which to take note:

1. Points have been created from the DTM to illustrate these points.
2. There is no point description to identify what the Nodes represent.
3. The numbers do not run consecutively (1,2,3…), nor are they incremental (2,17,25…).
4. The spacing of the Nodes is a characteristic of a DTM, i.e., they are very close together.

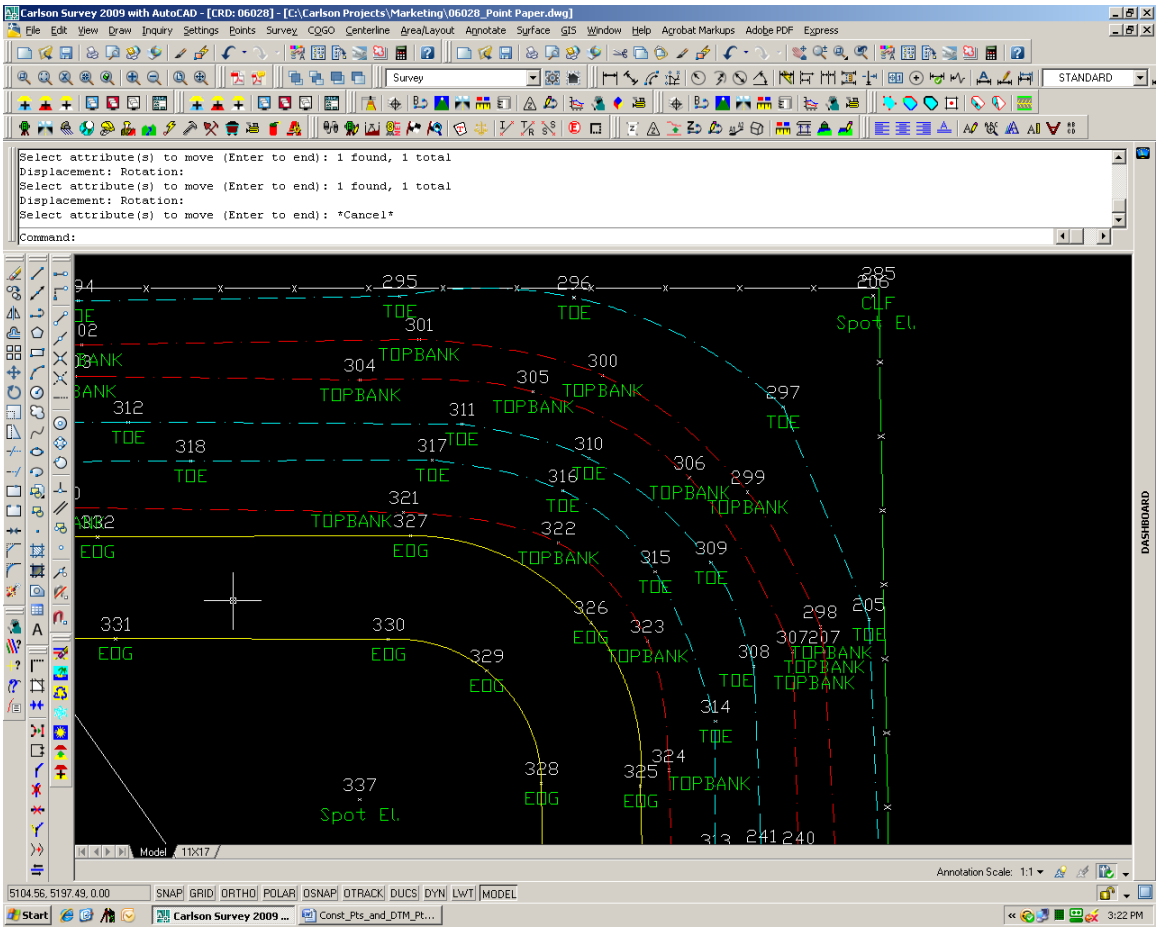

Figure 2

Figure 2 is a plot of the same area and shows Database points or COGO points and corresponding line work. There are several significant issues of which to take note here as well:

1. There are point descriptions to identify what object the points represent. Although some are coded (EOG = Edge of Gravel), we are still able to determine the object that the data point defines.
2. The points run consecutively (1,2,3…) in some cases, but they are incremental (2,17,25…) in all cases. This is significant for the office plan production as well as the field stakeout.
3. The spacing of the points is based on critical elements. The critical elements in this scenario are defined as changes of horizontal and vertical alignment.

**Organization of Data in the Point Database**

Data sets often consist of thousands of points. These points are often called COGO points. It is necessary that some type of organization take place.

To discuss the various methods of data set organization is beyond the scope of this discussion. Some of the more critical elements are defined as:

1. Assigning a description to the different types of data. - In Figure 2, there are multiple instances of the EOG, Toe and Top Bank. A common method of organizing the subsets is to name one EOG line as EOG1 and the other EOG line as EOG2. The same method would be used for the Toes and Top Banks.
2. Assigning a range of points to a specific data type. - An example of this is to have all of the project control points assigned a point value between 1-100. To further define this system, all of the existing topographic location points could be between 200-800 and so on.
3. Assigning consecutive point numbers that increase along a specific direction. - In other words numbering all of the EOG points consecutively up station.
4. When it is not feasible to number the points consecutively, then numbering the points incrementally is important.

**Value of Data Organization**

The preparation of maps and plans is very similar to construction point stakeout. In both actions we are using a series of points to define a line or object of some kind. The obvious difference is that the map and plan production is performed in an environmentally controlled work space. Construction stakeout is very different in that we are required to deal with difficult weather conditions and working around construction machinery that can seriously hurt us or our equipment. Both environments deal with stress, but it can be argued that the type of stress is different as well.

Construction stakeout with modern technology is just as rigorous as performing coordinate geometry in an office environment. The reason is that the stakeout personnel are performing coordinate geometry in the field. Besides that, office workers don't have that project superintendant looking over their shoulder saying "when" and the bulldozer sitting there not working. That's stress with a capital S.

Consecutive and incremental point numbers along an object are a benefit to both environments. By example, in my preferred CAD software, I can define a line to be drawn by specifying the descriptor and further defining that I want the line to be drawn based on incrementally larger point numbers.

Construction stakeout requires a greater amount of data input in that the occupation point and backsight point (in Total Station surveys) be defined and that each point that I want to stake be defined as well. In the stakeout process, most data controller software will default to the next higher point number when I complete a point stakeout. If the points are not consecutive, then I must review a printed stakeout sheet or graphic on the data controller screen to determine the next point to stake. This can be a very time consuming undertaking given the amount of equipment that I must carry and is not made any easier when the bulldozer runs by me kicking up enough dust to choke me.

**DTM Data Sets or Surfaces**

Most DTM data is in the form of a Triangular Irregular Network or TIN. A TIN is formed by creating triangles between groups of x,y,z (easting, northing, elevation) elements through all of

the data in the project area. A TIN does not create points per say, A TIN creates data which is termed nodes and 3D Faces. The triangles are formed in a clockwise direction. The TIN is what we refer to as the model.

The TIN file, if printed out will have lines of data that contain the x,y,z definition of a node. The line number is simply a line number and not a point number from which geometry can be established. It is possible to assign point numbers in the traditional sense to the nodes, but the point numbering will be consistent with the triangle which is formed. In other words, the point numbers will follow the direction of the triangles that are created for the TIN. It is impossible for a TIN to create consecutive point numbers along a line (by example an EOG) and since the point numbers are created by triangles it is very nearly impossible for the points to be incremental along an object.

There are no curved lines in a DTM. Each curvilinear object is broken into chords and since the chords tend to be very short, this is one reason that there are so many more points in a DTM compared to topographic survey or design.

**Examples of Data Contained in the Point Database (COGO) File**

```
- <CgPoints>
  <CgPoint name="1" desc="OLDSYS">5062.963 4848.697 82.480</CgPoint>
  <CgPoint name="4" desc="MISC/TBM">5027.430 4977.536 86.001</CgPoint>
  <CgPoint name="5" desc="EOG1 jpn333">5208.416 4985.334 84.297</CgPoint>
```

**Examples of Data Contained in the TIN Node File**

```
- <Surfaces>
- <Surface name="06028_2">
- <Definition surfType="TIN">
- <Pnts>
  <P id="1">5005.062 5076.276 82.300</P>
  <P id="2">5005.108 5081.845 82.300</P>
  <P id="3">5001.098 5081.724 82.300</P>
  </Pnts>
```

**Examples of Data Contained in the TIN 3D Face File**

```
- <Faces>
  <F>325 320 342</F>
  <F>277 270 333</F>
  <F>136 148 88</F>
```

**Discussion**

The three examples above come from a LandXML output file. I have used the LandXML format because it is more descriptive of the data types. The common elements of the Point Database (COGO) file and the TIN Node file are:

1. Northing
2. Easting
3. Elevation

The differences are:

1. The points in the Point Database are defined by Cogo Point Numbers (CgPoint name) that are usable by mapping, plan production and field data controller softwares. The TIN Node file is defined by line number which is not usable by the aforementioned softwares.
2. The points in the Point Database have a descriptor which describes what the point represents and the TIN Node file does not.

Uses of the data:

1. The points in the Point Database can be used to create linework and other objects in CAD software. They can also be used for stakeout in data controllers.
2. The points in the TIN Node file are used for creating DTMs and contouring.
3. TIN data can be created from the points in the Point Database.
4. Stakeout data cannot be created from the points in the TIN Node file.

**Conclusion**

1. There is a common misconception that TIN Nodes and Point Database points (COGO Points) are the same thing. This is simply not true.
2. There is a significant relationship between the COGO points and the TIN Nodes on a project, but that relationship is limited to the elevation.
3. It is likely that a COGO point and a TIN Node exist in the same location. This does not change the significance of the TIN Node. In other words, a TIN Node that exists in the same place as a COGO point still cannot be used for COGO.
4. We cannot expect our stakeout personnel to do stakeout with TIN Nodes. It is very possible that your less experienced personnel might attempt to do so. But we are not in business to attempt to build anything, we are in business to build things and meet specifications.

As a construction contractor whose ultimate responsibility is to provide a project that is built to the specifications, you should question anyone who attempts to tell you that the modeling and stakeout process is simple.

- There is nothing simple about:
    - Creating a 3 dimensional model of every detail contained in a set of construction plans.
    - Checking each model element against a set of construction plans to make sure they are correct.
    - Creating stakeout data that exactly matches the plans and the model.
    - Staking the necessary points that match the plans and model to build your job.

When someone tells you how simple 3D Modeling and stakeout is, remember whether they have a contractual agreement to support your project by providing those services and the professional liability insurance to back it up.