Chapter 2

Civil Geometry

2.1 Objectives

- Understand and use Feature Definitions
- Create PI based horizontal geometry using the Complex by PI tool
- Use the OpenRoads Technology heads-up display and element manipulators
- Associate Design Standards with alignment geometry and review feedback when design standards are violated
- Import geometry from native geometry database
- Discuss using manipulators and handlers

2.2 Definitions

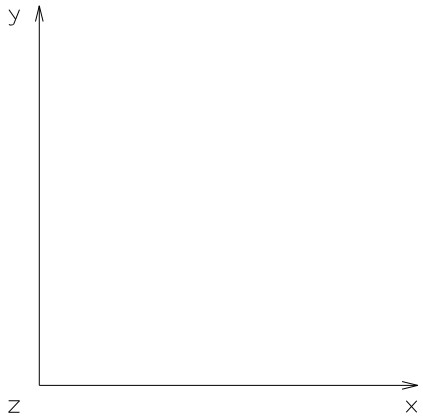
Civil Geometry is a dynamic, interactive, rules-based approach to geometry that provides an unprecedented level of associativity by preserving design intent, snaps and Civil AccuDraw input. The results of the tools are intelligent MicroStation graphic elements which can be dynamically edited and associations between elements are automatically updated.

In addition, the result of using the Civil Geometry tools are graphical geometry elements that are stored as MicroStation elements. No external geometry file is required. The MicroStation elements serve as the geometry elements with additional intelligence applied to store the rules and associations.

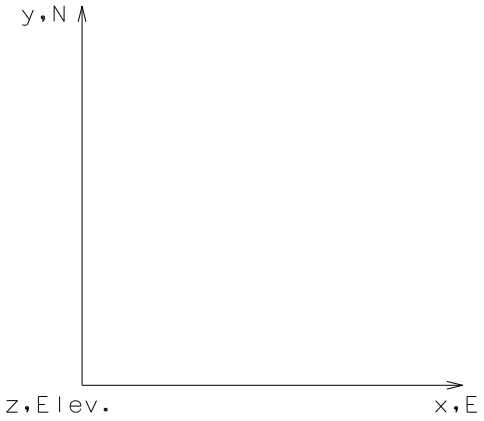
The Civil Geometry tools are installed as a part of GEOPAK. In order to be consumed by processes within GEOPAK, the civil geometry stored in the MicroStation elements must be written to the native application coordinate geometry .GPK file. This function can be configured to happen automatically based on properties of feature definitions, or it can be done manually.

2.2.1 Coordinate System

The Coordinate system is defined with **XYZ** Coordinates. The **X** and **Y** Coordinates define a horizontal plane, while the **Z** Civil defines the vertical dimension. All points in a civil geometry element are defined by at least an **X** coordinate and a **Y** Coordinate. If an elevation is to be stored, the **Z** Coordinate will also be defined.



The **XYZ** Coordinates can also be referred to in **Northing (N)**, **Easting (E)**, and **Elevation (Z)** Coordinates. The **Northing** Civil refers to the **Y** value, the **Easting** Civil refers to the **X** value, and the **Elevation** refers to the **Z** value.



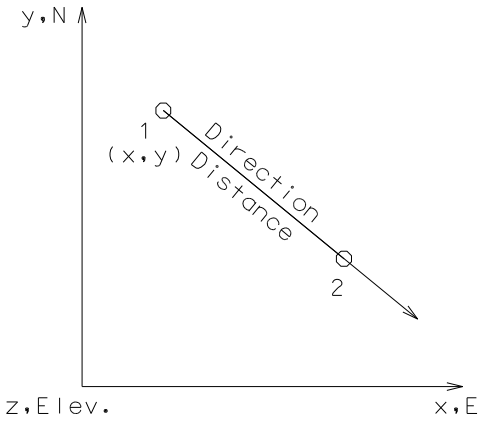
The user must be aware of the Coordinate system the data is in, and the Coordinate system that GEOPAK is using. When referring to the **XYZ** coordinate system, the Coordinates are listed as **(X, Y, Z)**. When referring to the **Northing, Easting, Elevation** coordinate system, the Coordinates are listed as **(N, E, Elev.)**. When translating this to the **XYZ** coordinate system, the Coordinates would be **(Y, X, Z)**.

2.2.2 Points

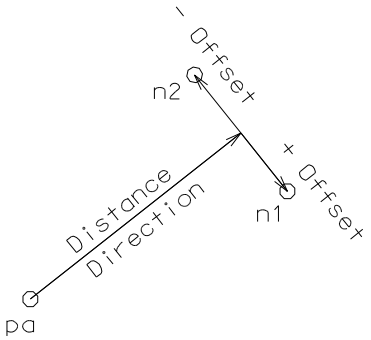
Points are defined by a single set of Coordinates. Each **point** will have an X and a Y Coordinate. The point may also have a Z coordinate if an elevation is defined.

Point names are alpha-numeric. If alphabetic characters are used, they must come before any numeric characters. The **point** name must contain at least 1 numeric character at the end of the name. Names can be up to 15 characters in length, although limiting the name to 8 characters is recommended.

Points can be stored from a set of Coordinates, or located from other elements. To define a point from another point, a distance and direction need to be defined.



Modifiers can be added to the direction and distance. An offset can be applied. This will locate the point at the specified distance and direction from the starting point, then perpendicular to the specified direction for the specified offset distance. A positive offset will go to the right of the specified direction, and a negative offset will go to the left of the specified direction.

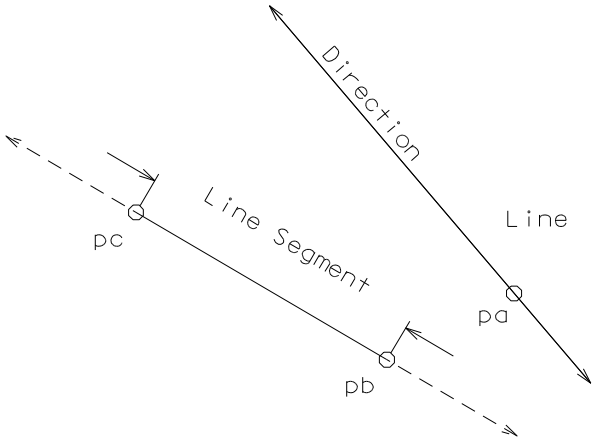


2.2.3 Lines and Linear Elements

Lines are defined by a location point and a direction, and are infinite in length.

Civil Geometry Linear Elements are a portion of a line that is defined by a beginning and an ending point.

Linear Element names can be alphanumeric up to 15 characters, but should not be numeric-alpha if the elements are going to be brought back to Native GEOPAK.



2.2.4 Curves

Curves are a segment of a circular arc. **Curves** can be defined by either the **arc method** (central angle that produces a 100' arc) or **chord definition** (central angle that produces a 100' chord). MoDOT uses the arc definition for all new alignments; however the chord definition has been used in the past, and may still be shown on old plans. This is configured in design file settings > Civil Formatting.

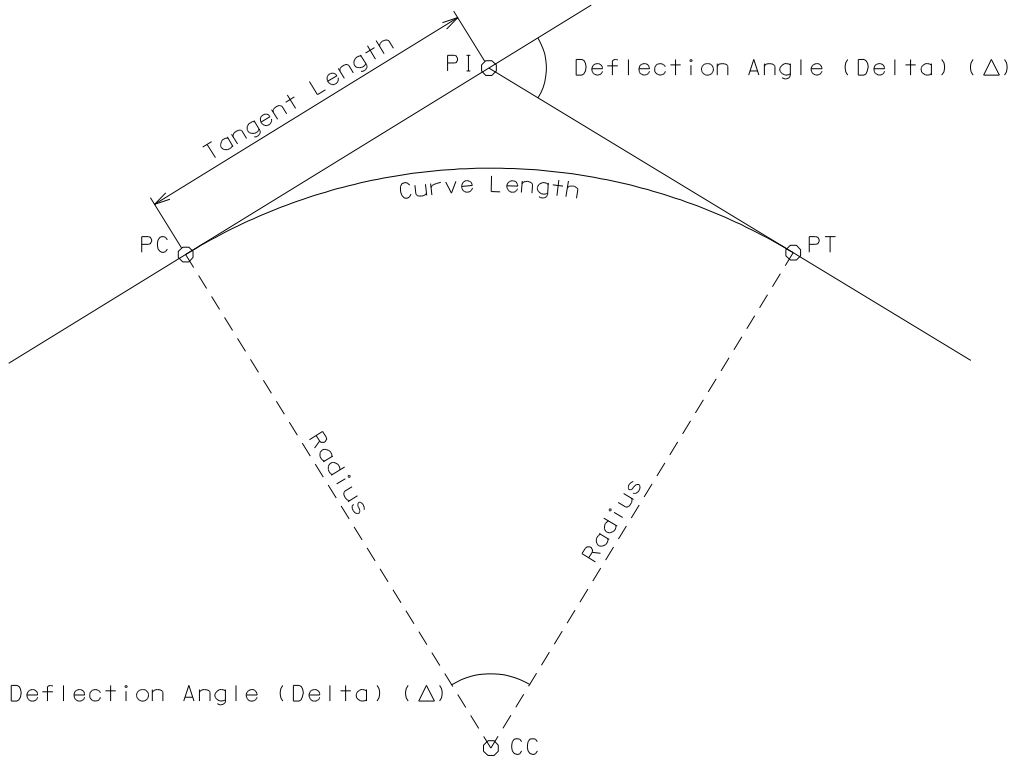
A **curve** has several points associated with it. These points help to define the **curve**, and are stored automatically when the **curve** is stored.

PC – Point of Curvature; Beginning of the curve.

PT – Point of Tangency; End of the curve.

PI – Point of Intersection; Point where the two tangents meet.

CC – Circle Center; Point at the center of the circle from which the curve is segmented.



Curve names can be any alpha-numeric characters up to 15 characters in length to be honored when brought back to Native GEOPAK.

2.2.5 Spirals

Spirals are a transitional curve. Typically a **spiral** will transition from a tangent (infinite radius) to a specified radius defined by a curve. **Spirals** can also transition between 2 specified radii as defined by 2 curves.

Spiral names can be any alpha-numeric characters up to 15 characters in length to be honored when brought back to Native GEOPAK.

Several points are also stored with a **spiral**. They are as follows:

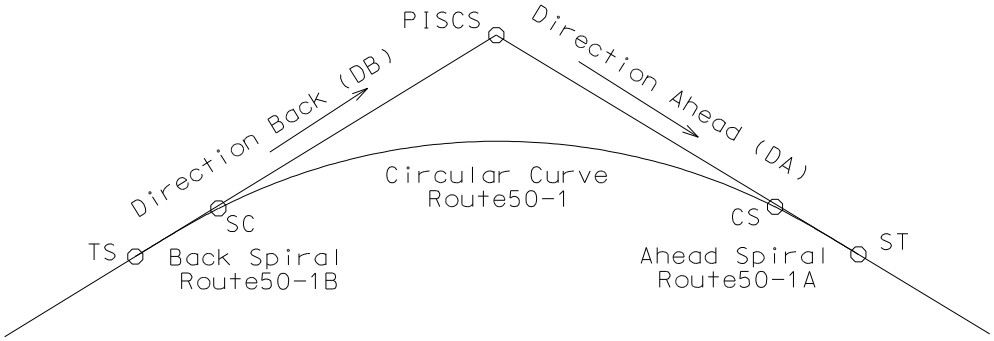
TS – Tangent to Spiral Point

SC – Spiral to Curve Point

CS – Curve to Spiral Point

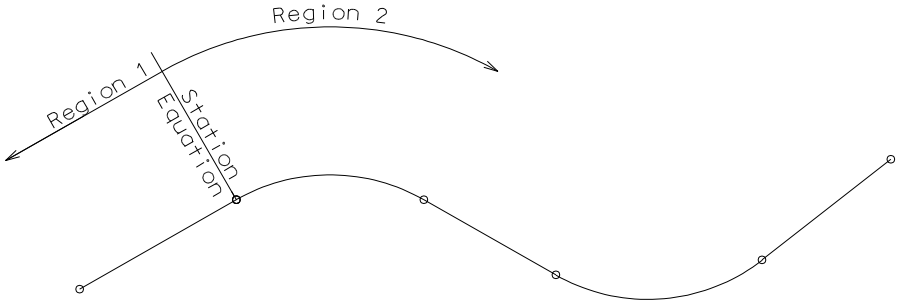
ST – Spiral to Tangent Point

PISCS – Overall Point of Intersection for the spiral-curve-spiral combination.



2.2.6 Chains

Chains are a combination of other elements. They can consist of points, curves, spirals, or other chains. Chains can represent horizontal alignments, or the horizontal location of some element. Chains have *stationing* associated with them. Locations along the chain can be determined by the stationing. If the stationing is adjusted along the chain a *station equation* is used. The *stations from the beginning of the chain to the first station equation* are referred to as **Region 1**. The *stations from the first station equation to the second station equation or the end of the chain* are referred to as **Region 2.**

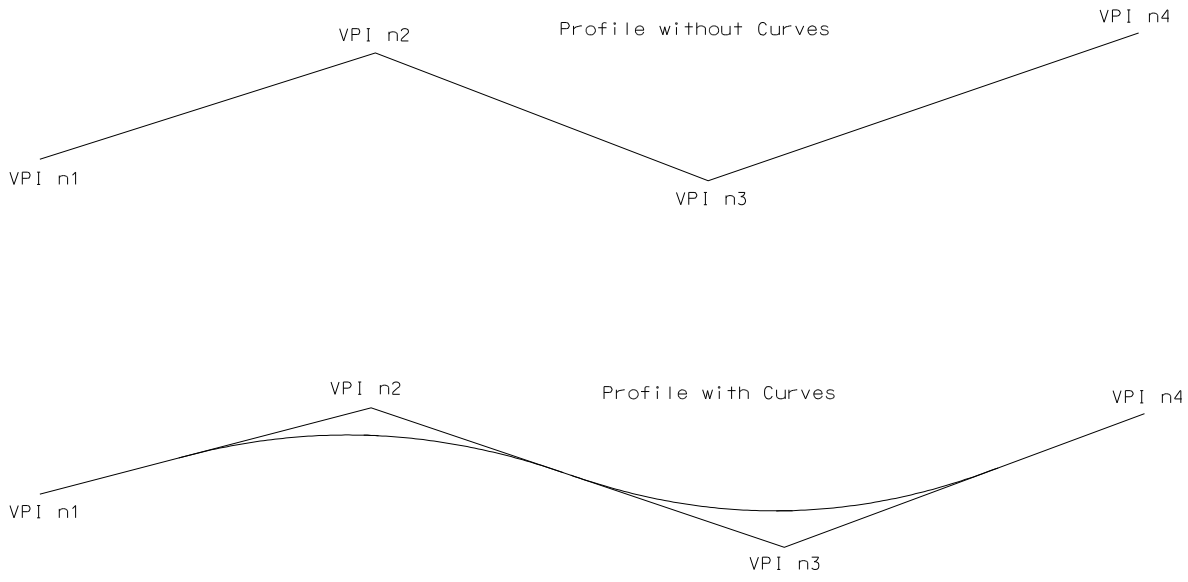


Chain names can be any alpha-numeric characters up to a length of 15 characters.

2.2.7 Profiles

Profiles are vertical alignments defined by stations and elevations. They are associated with some horizontal plan element. Profiles can be stored with or without vertical curves. Profiles

without curves generally represent the existing ground profile, or a ditch profile. Profiles with vertical curves are generally used as proposed corridor.



2.3 Open Roads Preferences

The seed files delivered in the workspace have MoDOT design file preferences configured.

2.3.1 Workspace Preferences

This dialog provides settings for the cursor prompt, manipulators, and various operational toggles. Enable this dialog from the *Workspace > Preferences* menu and selecting the **View Options-Civil** category.

Manipulator Settings

These settings allow the user to control the settings and symbology of the civil geometry manipulators and any associated text.

Superelevation Settings

When the super elevation components are drawn into the design file, these two options allow the user to specify whether they are to be drawn as Color Shaded Fill or Boundary Only.

Survey Locator

This setting is used by the Survey tools to control the display and symbology of the locator.

Maximum Error Ellipse

Survey only - This setting allows the user to specify a major error ellipse value with regard to the standard deviation resulting from a Least Squares Adjustment. Any standard deviation exceeding this limit results in a graphical flag based on this symbology.

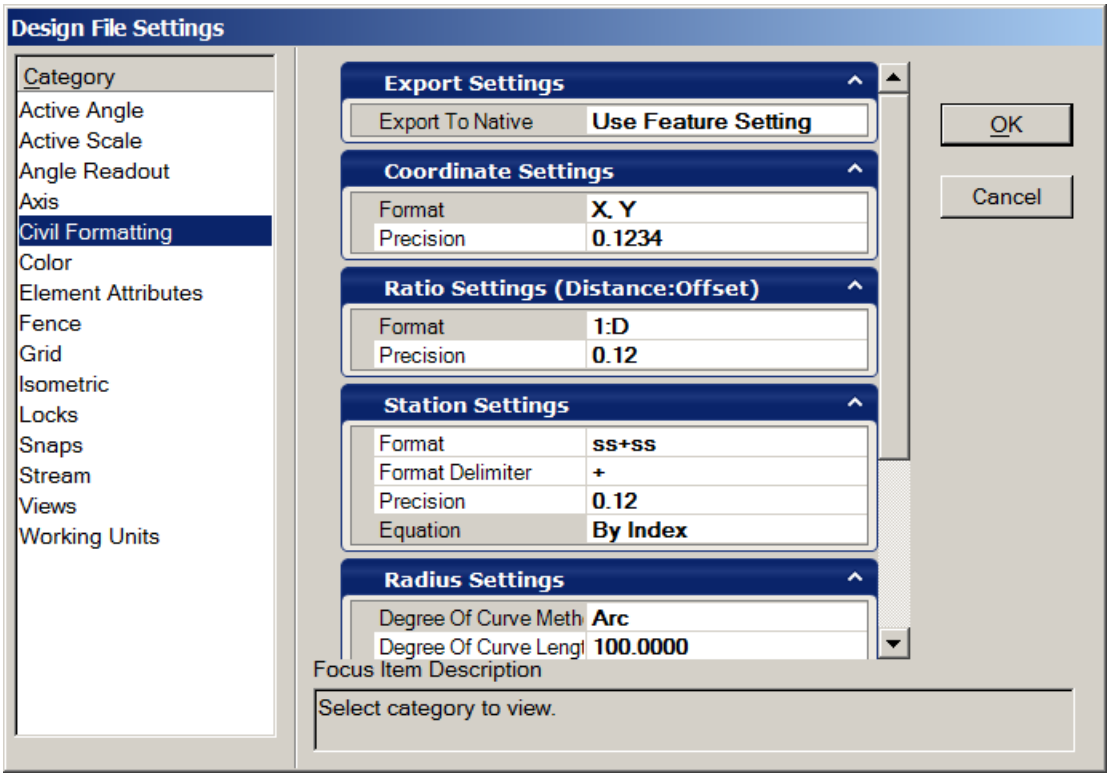
Medium Error Ellipse

Survey only - This setting allows the user to specify a medium error ellipse value with regard to the standard deviation resulting from a Least Squares Adjustment. Any standard deviation exceeding this limit results in a graphical flag based on this symbology.

Minimum Error Ellipse

Survey only - This setting allows the user to specify a minimum error ellipse value with regard to the standard deviation resulting from a Least Squares Adjustment. Any standard deviation exceeding this limit results in a graphical flag based on this symbology.

2.4 Design File Settings



Design File Settings dialog provides options for civil settings that control civil annotation within the design file. Enable this dialog from the *Settings* > *Design File* menu and selecting the **Civil Formatting** category.

- **Export Settings**

  When *Export to Native* is set to **Use Feature Setting**, the native geometry database (.GPK, .ALG, .FIL) will sync with civil geometry stored within the design file. For

example, the user can store an alignment in the design file and that alignment will be automatically stored in the native geometry database as well. Delete an alignment from the design file, and that alignment will be deleted from the native geometry database. The Export to Native functionality is feature based in that the option to ”Export to native” must be set to ”true” or ”false” for each particular feature.

If *Export to Native* is set to **Manual**, the native geometry database will have to be updated manually.

- **Coordinate Settings**

  Controls the display and precision of their coordinates within any of the civil dialogs. In addition, this setting also controls how any inputted coordinates are interpreted. For example, if set to “X, Y” then all coordinates are interpreted and displayed as being in the “X, Y” format. If set to “Nothing, Easting” then the same applies.

- **Ratio Settings (Distance:Offset)**

  Controls the display and precision of ratios within any of the civil dialogs. In addition, this setting also controls how any inputted ratios are interpreted. For example, if set to “1:D” then all ratios are interpreted and displayed in this format (1:100, 1:50, etcetera). If set to “D:1” then the ratios are similarly displayed and interpreted (5:1, 10:1, etcetera).

- **Station Settings**

  Controls the format, delimiter and precision of the station values to be used and displayed in the civil dialogs. **Equation** can be set to:

  By Name - This is the standard InRoads presentation (A100+00, B105+00, etcetera).

  By Index - This is the standard GEOPAK presentation (100+00 R 1, 105+00 R 2, etcetera).

- **Radius Settings**

  Degrees of Curve Method - Two options are available, *Arc* and *Chord*.

  Degree of Curve Length - This sets the standard definition of a 1 degree of curve.

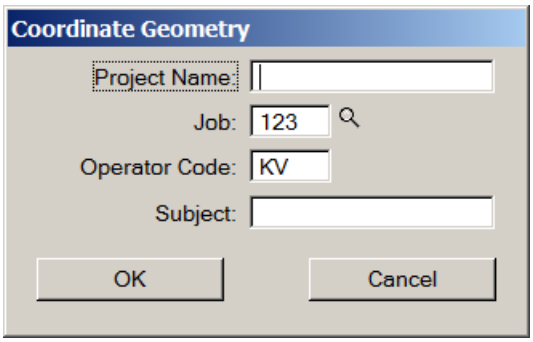
  Radius Toggle Char - This allows the user to specify which character will be used within the civil dialogs to ‘toggle’ between a radius definition and a degree of curve definition. The letter **d** is the default setting.

- **Profile Settings -** Controls the precision and display or input formats of slopes and ratios within a profile context. In addition, sets the default Vertical Curve Parameter Format (Radius, K Value or M Value).

2.5 Accessing

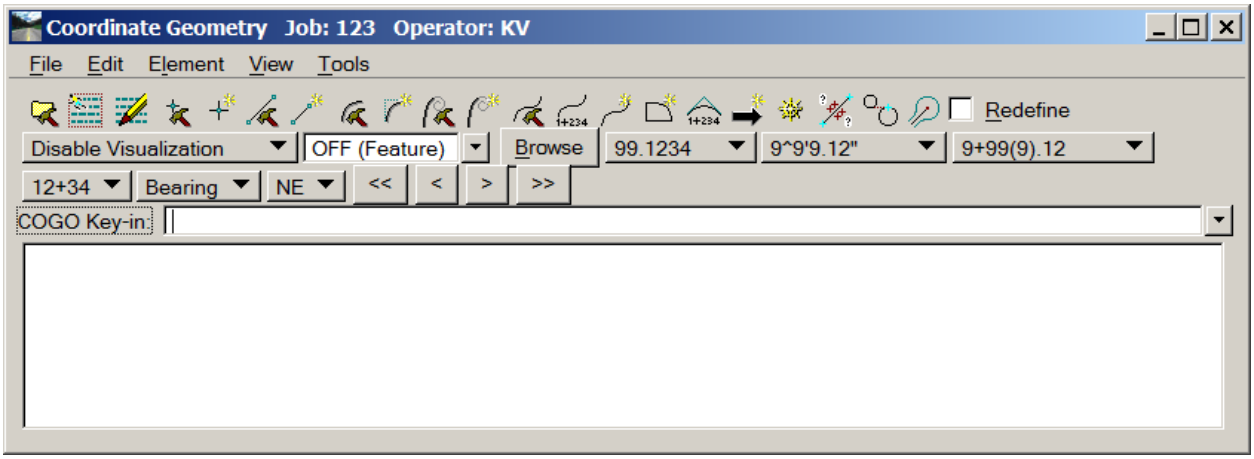
When designing with the Open Roads technology in GEOPAK the geometric data can be written back to the native .gpk. Having an active GEOPAK project facilitates this capability.

To setup *Coordinate Geometry* project values, choose the **GEOPAK > ROAD > Geometry >Coordinate Geometry** command and the data in the *Coordinate Geometry* dialog as noted below.



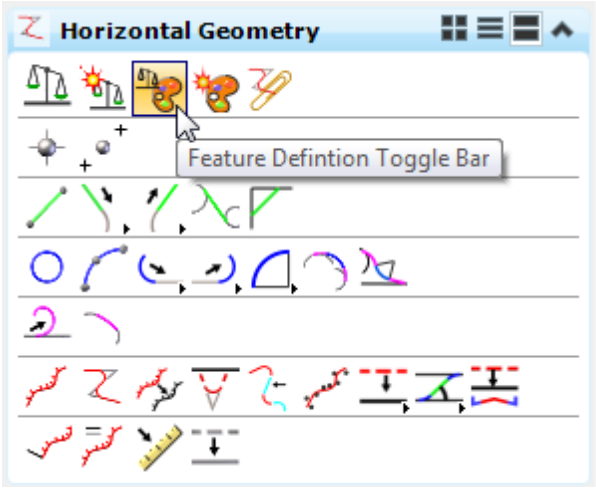
- **Project Name:** defines the name displayed on reports (60 alphanumeric characters max) (*Optional*).
- **Job:** identifies the Civil geometry database (3 alphanumeric characters, max) (*Required*).
- **Operator Code:** identifies a unique 2-character operator code. Allows multiple user access to the database. (*Required*) (User's initials suggested).
- **Subject:** description of work (48 alphanumeric characters, max) (*Optional*).

Once these parameters have been defined, the *Coordinate Geometry* dialog box will appear.

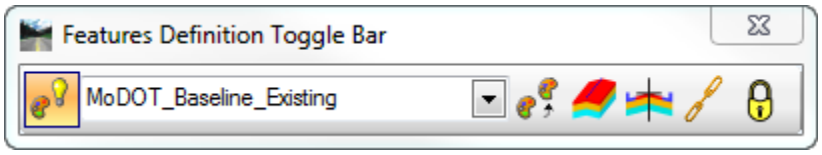


2.6 Features and Feature Definitions

Access the **Feature Definitions Toggle Bar** from the *Horizontal Geometry* tasks group.



Having the *Definitions Toggle Bar* open and available is very useful for expediting the association of a feature definition to a new geometry feature.

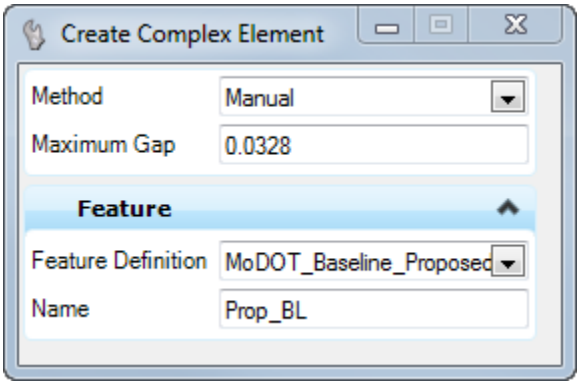


Feature definitions are used to define options when creating features. These are the items which are created in advance, usually used across multiple projects, and define symbology, annotation and quantities. The feature definition is assigned (usually) in the plan model, and optionally in profile and 3D feature definitions.

A Feature is anything that can be seen or located and is a physical part of your design representing a real world entity. Examples include curb and gutter, pavement, power lines, trees, etc.

A feature's definition is one of its properties. At any given time in the design process, the feature will have horizontal geometry, vertical geometry, 3D geometry or a combination to define its location. Generally, the feature's definition is assigned at time of creation, but can be assigned after-the-fact.

Most Civil tools have entry fields for *Feature Definition* in their dialog as illustrated below.



The rules applied to Feature Definitions are:

- If no Feature Definition is selected, the active MicroStation symbology is used and no feature is defined, but you can define a Name Prefix.
- If a Feature Definition is assigned, a Name Prefix is applied, and the symbology, attributes, and annotation defined in the feature definition are applied to the element.

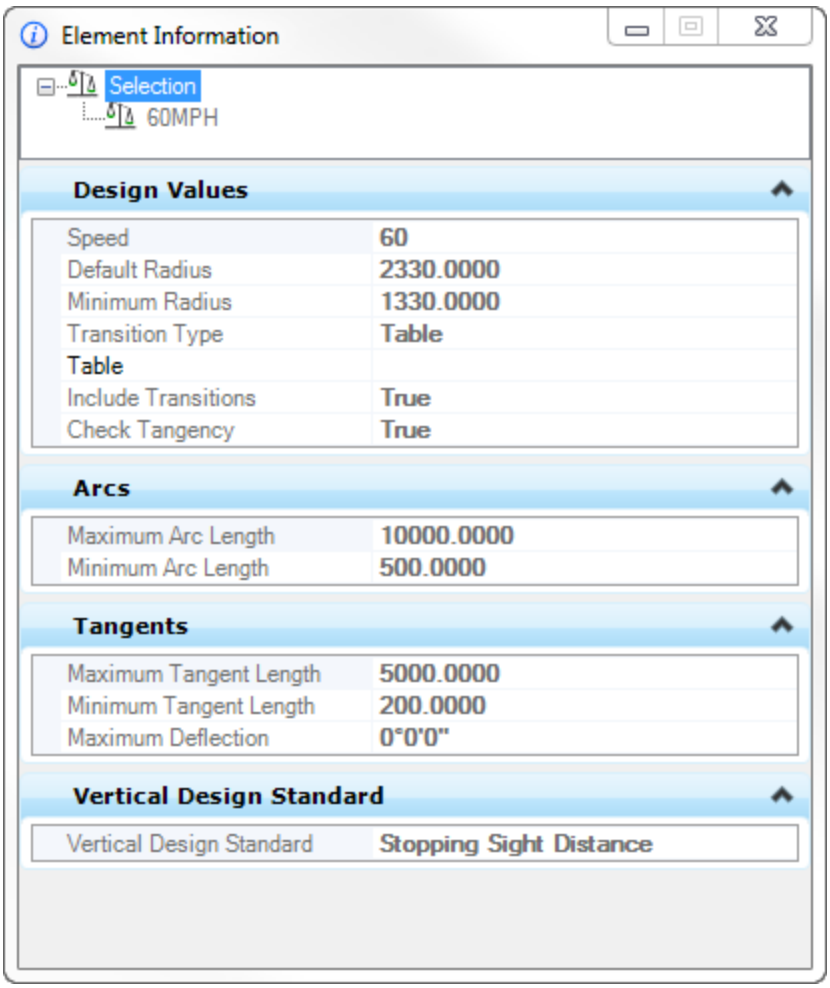
2.7 Design Standards

Design standards are used to monitor required curvature and other alignment checks on horizontal Civil Geometry elements and slopes and K values on vertical geometry elements. The standards are stored in a design library (DGNLIB) which can be read-only and stored in a central location for use by all users and referenced by the configuration variable MS_DGNLIBLIST. A DGNLIB is an empty file (does not contain any MicroStation elements) similar to a seed file where you can set up various MicroStation and Civil resources. An organization can utilize numerous DGNLIBs to facilitate management of their standards. For example, horizontal and vertical standards could be stored in one DGNLIB while other standards would be defined in other DGNLIBs. If utilizing both Metric and English units, you may want a separate DGNLIB for each.

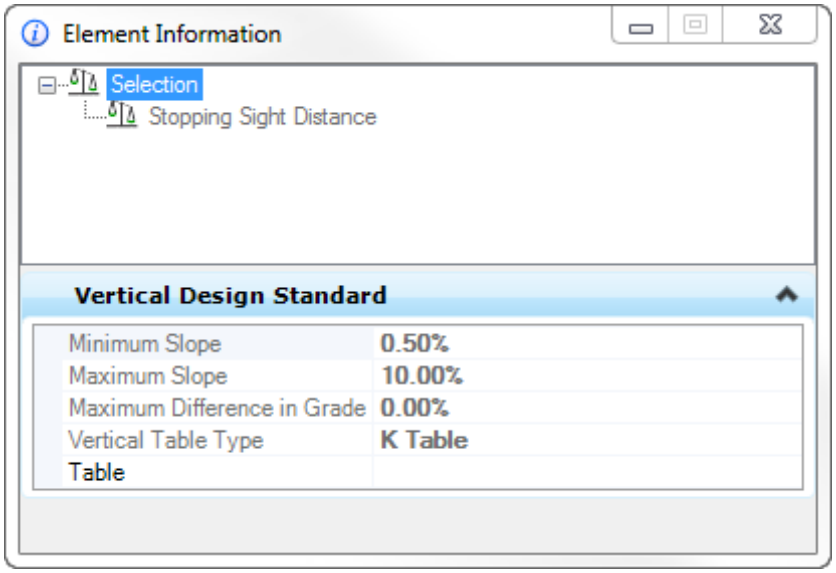
The standards are set up within the Project Explorer. Note the hierarchy from the Project Explorer is mirrored in the Design Standards Tool Bar pick lists. The hierarchy is customizable to conform to your organization's standards. As most organizations utilize AASHTO standards, the default libraries included in the installation package are based on the 2001 and 2004 versions of "A Policy on Geometric Design of Highways and Streets."

The Project Explorer is accessed by selecting *File > Project Explorer* from the main menu or from the Primary Tools menu bar. It is more efficient to complete the vertical standards first, as they are referenced when building the horizontal standards.

Right-click on the individual entry and select Properties from the pop-up menu to review the settings.



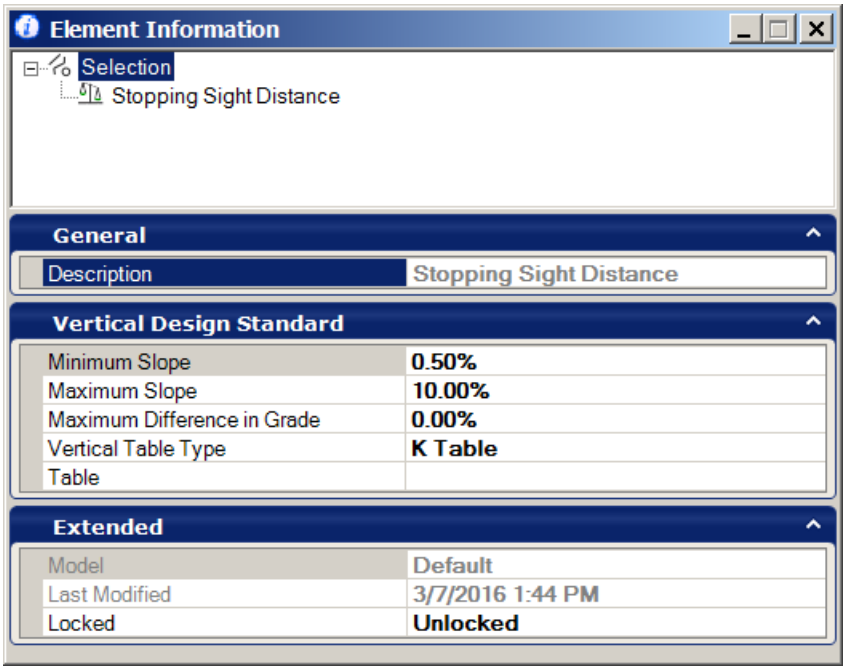
Horizontal Design Standards Properties



Vertical Design Standards Properties

2.8 Viewing and Accessing Horizontal and Vertical Standards

The Design Standards branch lists the design standards that are available within the active design model or a DGN library. The Design standards defines Design standards that are used to assist the designer in maintaining required curvature and other checks when performing geometric layouts and are normally based on accepted standards for a geographic area or authority, these standards are stored in DGN libraries.



The properties for each Horizontal standard are:

- **Design Values**

Speed - this is the design speed for the standard.

Default Radius - this is the radius used to populate commands when initiated.

Minimum Radius - this is the minimum radius for the corresponding design speed. Utilizing values lower than this radius will cause a warning to be displayed.

Transition Type - can be by Table or Equation.

Table - If transition type is table then this is used to populate the table.

Include Transitions

Check Tangency

- **Arcs**

  Maximum Arc Length

  Minimum Arc Length

- **Tangents**

  Maximum Tangent Length

  Minimum Tangent Length

  Maximum Deflection - the maximum angle between the lines where two tangents join without a curve.

The properties for each Vertical standard are:

- **Vertical Design Standards**

  Minimum slope

  Maximum slope

  Maximum difference in grade

  Vertical Table Type

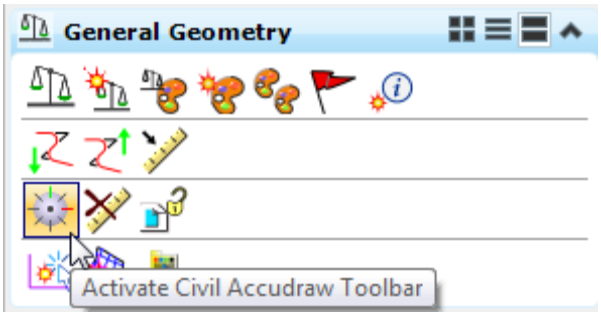
  Table

2.9 Civil AccuDraw

Civil AccuDraw performs many of the same functions as *MicroStation AccuDraw* but has greatly expanded capabilities for the civil designer. It allows the user to define a point location at any stage of any placement tool (MicroStation or Open Roads) and accept input that results in more sophisticated point locations.

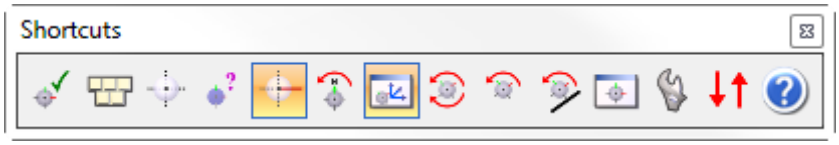
Accessing Civil AccuDraw

Civil AccuDraw can be accessed from **Tools> Civil AccuDraw > Activate Toolbar** or from the Civil Tools task menu **General Geometry > Activate Civil AccuDraw Toolbar**.



It is recommended that the Civil AccuDraw Toolbar be docked to facilitate use.

The shortcuts have key-ins and are also mapped to icons.  Having the *Shortcuts Toolbar* active and docked can also be a time saver.



Benefits

There are many benefits in using Civil AccuDraw.

1. It extends the drafting power of MicroStation by providing Civil point location methodologies in all the MicroStation and Civil commands. For example, a user will be able to place a cell at an offset using the normal place cell but invoking Civil AccuDraw to enter the station and offset.
2. It will eliminate the need to create temporary construction geometries just to perform more complex point locations. For example, to place a line at a given distance from 2 points a user would need to draw 2 circles at each point with the desired offset as the radius of each station and then place a line tangent to these circles, and finally delete the

unwanted circles. Civil AccuDraw provides a Distance from Point snap where the point can be identified, the offset entered, and the data point applied to the construction.

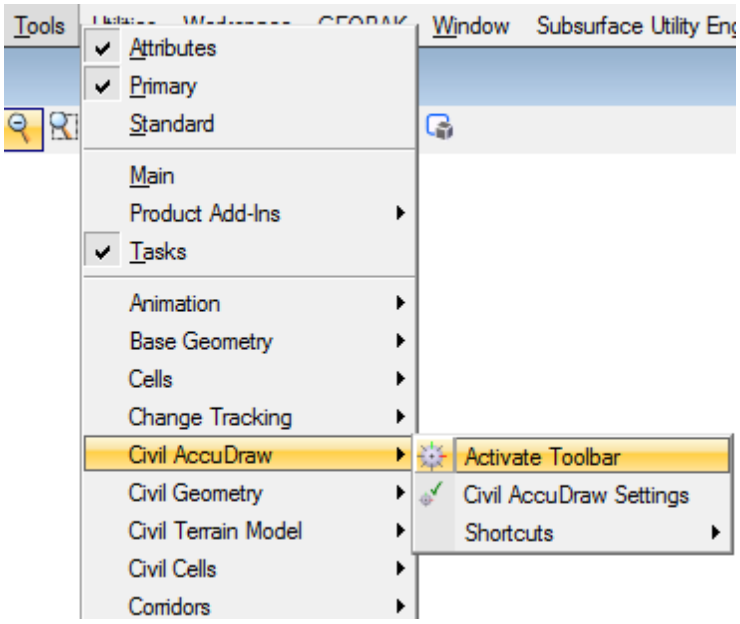
3. When used in conjunction with the Civil Geometry commands the resultant elements are constrained by rules set by the selection of the Civil AccuDraw ordinates.
4. The Civil Geometry heads up display options are enhanced when Civil AccuDraw is active and the options available are determined by the method selected.

Use Tips with the Geometry commands

1. Selecting the Tab key while in an entry field will change focus.
2. Selecting Enter will set the value in the field and lock it
3. Selecting the End key will unlock the field
4. Selecting the left or right arrow key will move through the favorite options.
5. Selecting the down key will bring up the associated command entry dialog in addition to the heads up display.

2.9.2 Civil AccuDraw Overview

1. Open any Design file (.dgn) file.
2. To open the *Civil AccuDraw Toolbar*, select **Tools > Civil AccuDraw > Activate Toolbar**



The *Civil AccuDraw* toolbox will open.

 Toggle Civil AccuDraw on/off.

 Drop down list of various tools including Civil AccuDraw settings and common shortcuts. This drop-down is also available by pressing space bar when any Civil AccuDraw field has focus.

These are the ordinate systems delivered in a default installation.

- Distance – Direction
- Distance – Direction Unlinked with two origin points
- Distance – Distance
- X – Y
- Dx – Dy
- Station – Offset
- DeltaStation-Offset

In a three dimensional design file there are two additional icons

 Sets the elevation ordinate

 ProfileOffset.

Some differences between the MicroStation AccuDraw tool and the Civil AccuDraw tool:

a. Civil AccuDraw compass will always point north regardless of view rotation.

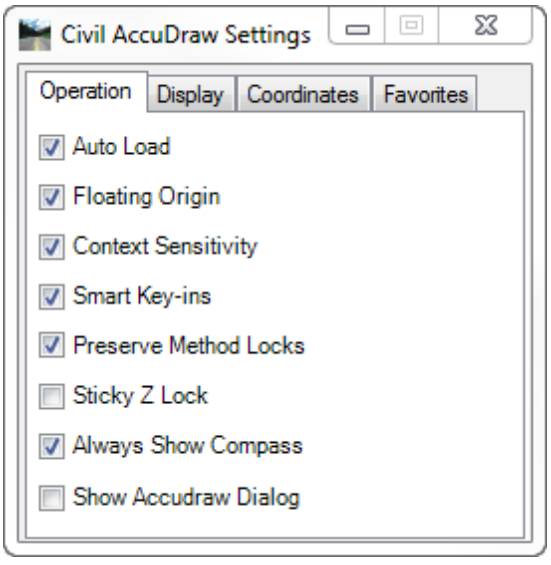
b. Civil AccuDraw uses a heads-up on-screen prompt at the cursor to allow precise key-in of distance and direction. A fixed dialog box becomes available when the down arrow is selected.

c. The Civil AccuDraw compass will always be circular. MicroStation AccuDraw changes the compass to rectangular for Cartesian ordinate systems.

 **Civil AccuDraw Settings**

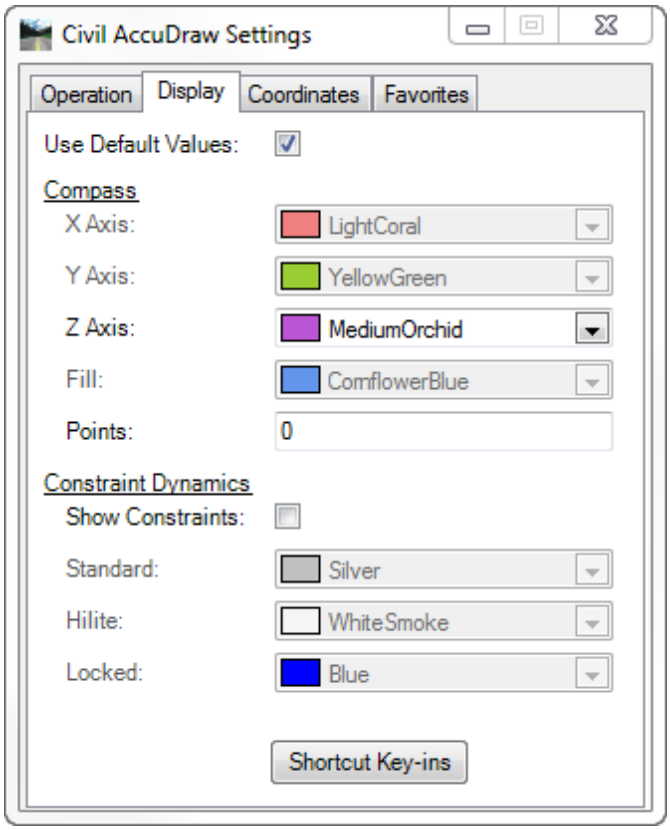
The **Operation** tab is similar to that of MicroStation AccuDraw.

- Operations of the same name have the same function in both AccuDraws.
- Selection or de-selection in one AccuDraw does not affect the selection in the other AccuDraw.
- Selecting the Show AccuDraw Dialog will result in the dialog and the heads up display both being available to the user during element placement.



The **Display** tab contains settings for:

- Color of compass axis
- **Points** configures the number of points in the compass circle
- Color of the constraint lines
- Whether you want to see the constraint lines and color of the constraint lines

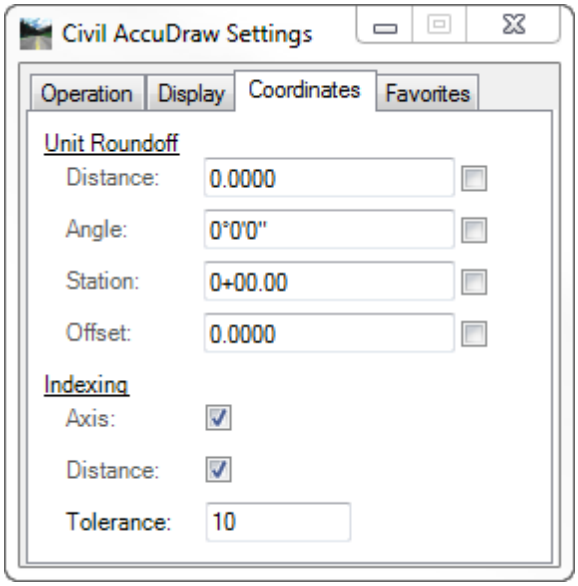


The shortcut button brings up the same shortcut list as used by MicroStation AccuDraw.

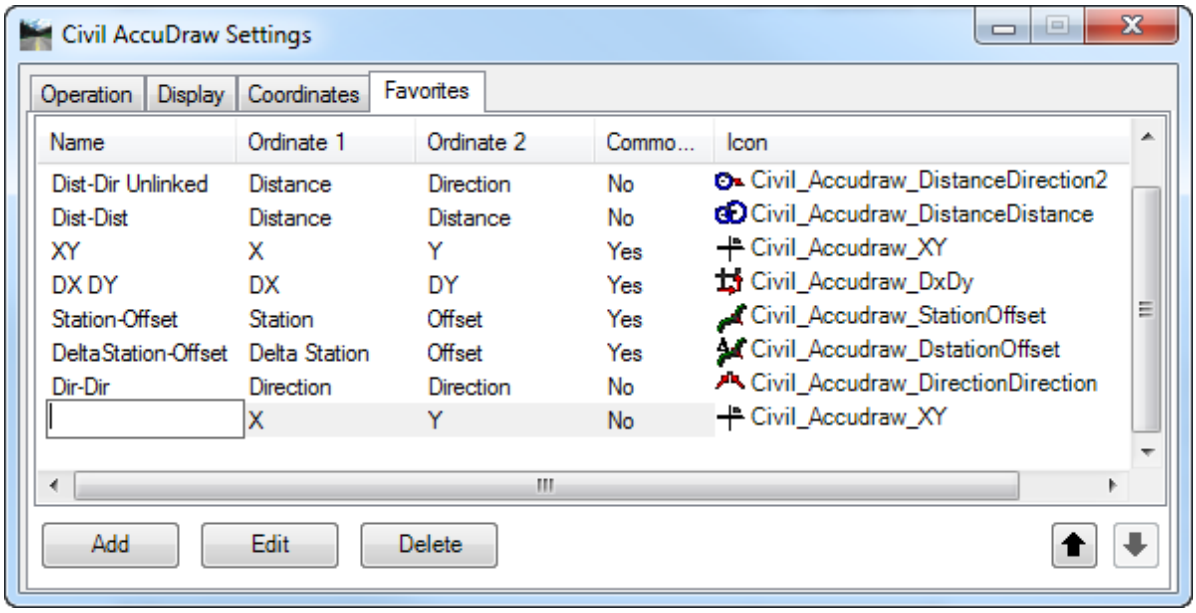
Both AccuDraws access the same shortcut.txt file.

The **Coordinates** tab contains the same round off and indexing settings as MicroStation AccuDraw and function the same way.

- Civil AccuDraw has additional settings that are provided to allow the round off of **station** and **offset** values.
- The numbers must be changed to values other than zero to be accepted.



The **Favorites** tab allows for the configuration of the most commonly used ordinate systems. It is one of the primary differentiators between Civil AccuDraw from MicroStation AccuDraw. The favorite selected determines what input fields are available during the placement of an element.



Ordinate 1 and Ordinate 2 are the measurement methods used in determination of the coordinates.

Common Origin has a *Yes/No* option.

- **Yes** indicates that both ordinate measurements come from the same origin location.
- **No** indicates each ordinate has a different location.

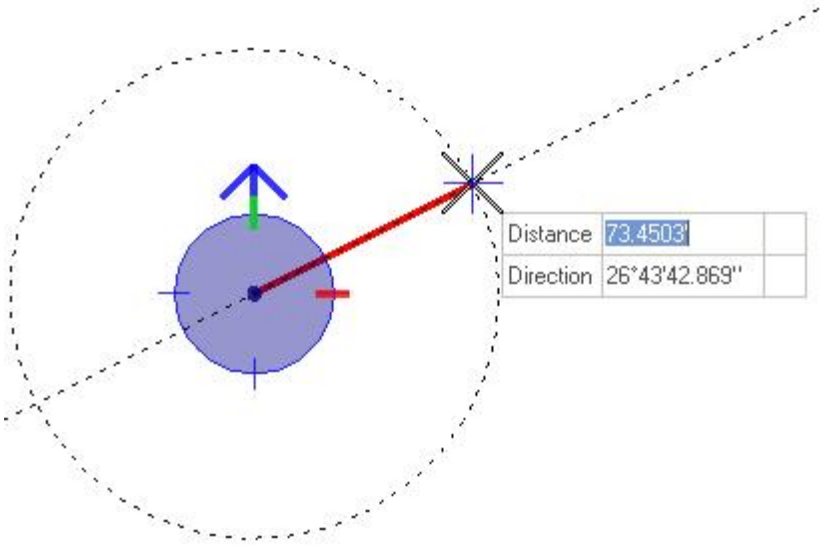
To add a new favorite:

1. Select Add
2. Key in the Name
3. Select the Ordinates.
4. Select whether the ordinates share a common origin.

2.9.3 Simple Linked Favorite Civil AccuDraw Workflow

A **Linked** favorite has two ordinates or measurement methods that share the **same** *Point of Beginning (POB)* or Origin.

1. Ensure *Civil AccuDraw* is active. If it is active then the first icon in the toolbox will have an orange background.
2. Set the active symbology or active feature. If no feature is assigned, the element will use *Default*.
3. Start the tool of interest and place the first point. This can be by XY= key-in or a data point. If the Civil AccuDraw XY favorite is active the X and Y fields will be available in the heads up display.

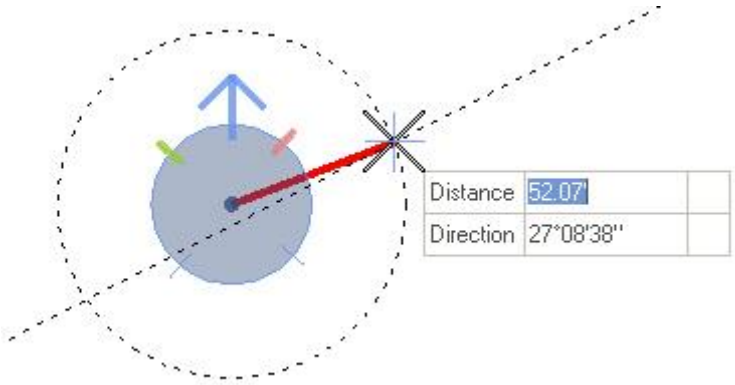


4.  Select the **Dist-Dir** favorite. Entries in the distance and direction fields present a dynamic circle and line feedback for the constraints.
5. Key in a distance and then press the **Enter** key to lock the distance.
6. As the cursor moves over one of the compass points (north, south, east or west) there is a color change feedback indicating a compass direction locks.
7. To unlock a value use the **End** key.
8. **Data Point** to accept the value.

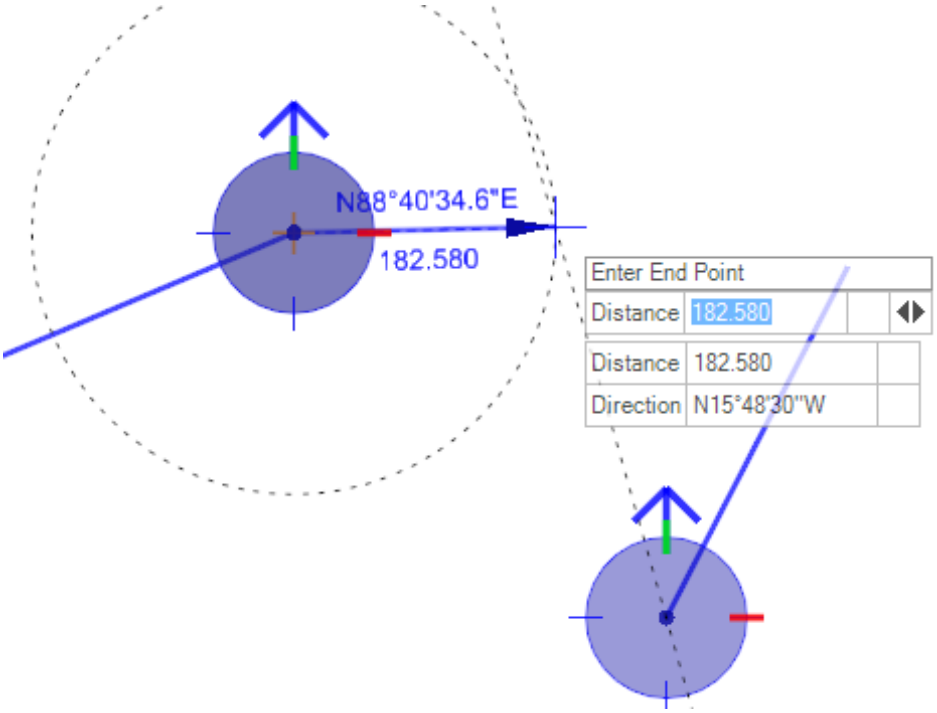
2.9.4 Simple Un-Linked Favorite Civil AccuDraw Workflow

An **Un-Linked** favorite has two ordinates or measurement methods each with a **unique** *Point of Beginning (POB) or Origin*.

1. Ensure Civil AccuDraw is active. If it is active then the first icon in the toolbox will have an orange background.
2. Select an element placement command.
3. Set the active symbology or active feature.
4. Start the tool of interest for example *Distance-Direction*. 
5. Place the first point. This can be by XY= key-in or a data point. If the Civil AccuDraw XY favorite is active the X and Y fields will be available on the Heads Up Display.
6. With the focus in the distance field press the letter (**O**) on keyboard. Then left click on the position to set the origin for measuring distance. This could be a graphical element, a terrain Model element, a Civil Geometry Element or a data point.

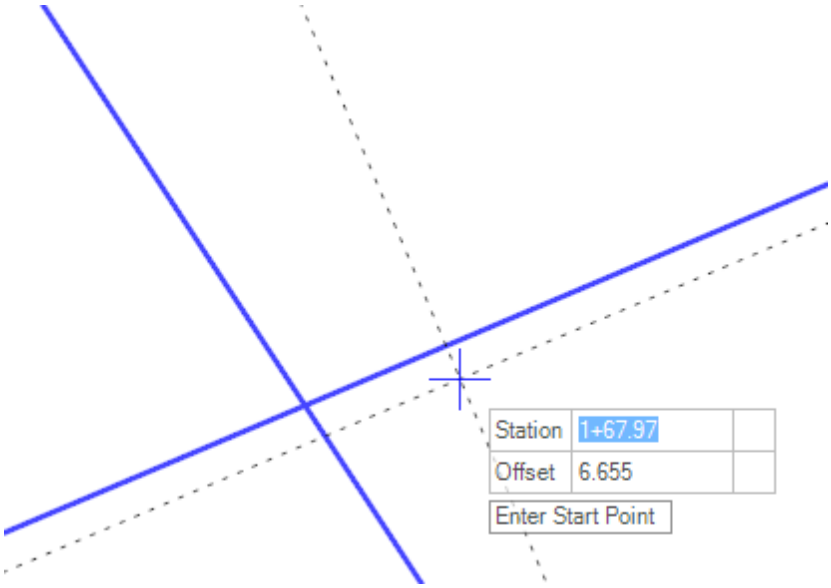


7. The origin shortcut (**O)** in Civil AccuDraw waits for a data point before setting the origin. This is to provide capability for the (O) shortcut to also choose the baseline for station offset ordinates.
8. Select the **Tab** key to move focus to the direction field, press (**O)** again, identify the location for the second ordinate point of beginning, and click a second data point to set the direction origin. This results in two independent compasses to measure the distance and direction. Both distance and direction can be locked as needed.



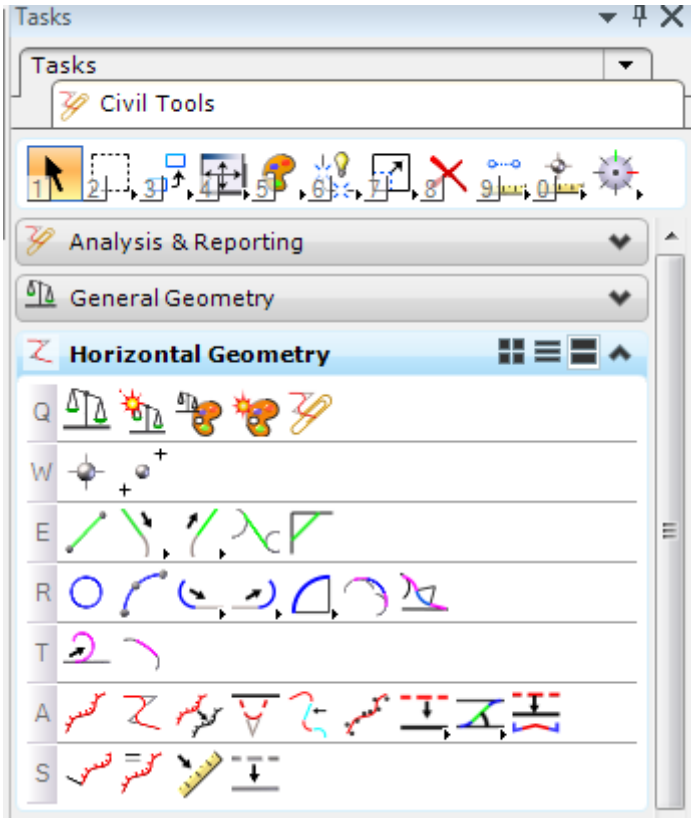
2.9.5 Station-Offset Linked Favorite

The **Station and Offset** linked favorite pulls the station and offset from the element identified after the origin shortcut (O) is entered. Selecting Tab will lock the value.

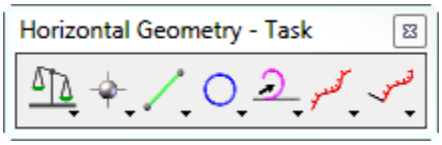


2.10 Civil Horizontal Geometry Commands

Civil Horizontal Geometry commands can be accessed by selecting the **Horizontal Geometry** task group from the *Civil Tools* tasks menu.



or by selecting **Tools > Civil Geometry > Horizontal Tools > Open as Tool Box** from the MicroStation menu.

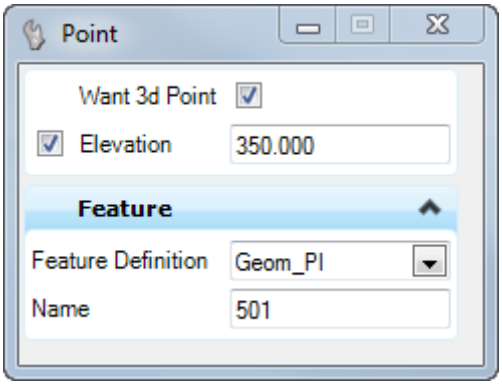


2.10.1 Placing Point Geometry

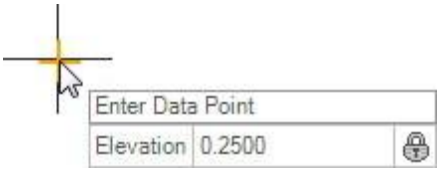
There are two point options; *Place Point* and *Equal Space Points*. 

Place Point constructs a civil point element. The point may place a cell based on feature definition or a MicroStation point (zero length line) if no feature definition is used.

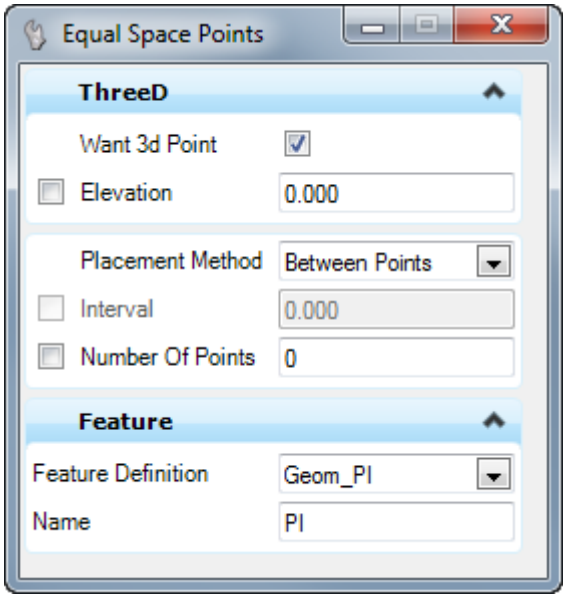
1. Open the Civil Tools task pane to the *Horizontal Geometry* section then click the **Point** icon. Selecting the Point icon will open the *Point* dialog. A 3D point can be created if given an elevation. Check the *Want 3D Point* box and enter an *Elevation* in the field provided if you wish your point to have a vertical value.



2. When you move the cursor into the View, it is equipped with a command prompt that says, *Enter Data Point*, so move the cursor to the location then place the data point to accept, or enter the XY value of the location in the MicroStation key-in field.



Equal Space Points inserts a specified number of points, points at a defined interval, or a combination of both into the View. These can be along an element or between two points.

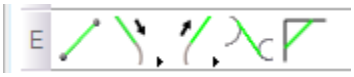


General Workflow

1. First select the **Placement Method** (*Between Points* or *Along Element*).
2. When using the Placement Method *Between Points*, select the location of the start point and key in the number of points. Select the location of the end point.
3. When using the Placement Method *Along Element*, select the element and select the Spacing type (Number Of Points option, Interval, Even, or Max Interval), key in the Interval or Number Of Points, and finally key in the Offset from the element

2.10.2 Placing Line Geometry

There are five linear element placement options



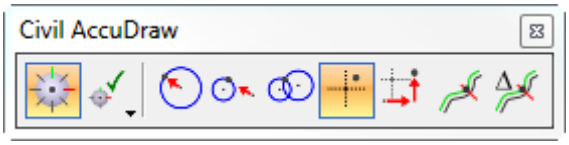
 **Line Between Points** – Places a line by Distance and Direction.

The points can be defined in several ways:

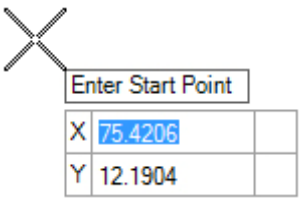
- Arbitrary Data Points on the screen
- Using Civil AccuDraw
- Snapped relative to other elements
- Previously created geometry point element
- Any of the values may be locked in the dialog when the tool starts or at any time while the tool is active. All of the values on the dialog are dynamically updated as the cursor moves

Without Civil AccuDraw active, the start point is identified and the distance and Direction entered to place the second point.

With Civil AccuDraw active and the *XY* favorite selected, a heads up prompt will provide XY key-in fields.



Changing the AccuDraw favorite will also change the heads up display presenting fields to define the location of the end point. If *Linked Distance-Direction* is selected in Civil AccuDraw then heads up display will have those fields.



 **Line To Element** – This is a series of *Line To Element* commands indicated by the arrow in the right hand corner of the icon. These pre-customized versions provide a simplified prompt sequence for many common construction tools. Right-click on the **Line to Element** icon then choose *Show/Hide Arc from Element Tools* to access the following options.

 **Simple Line To Element -** Creates a line without any transition to another element at zero degrees skew angle; applicable only when the *To* element is a curve, *Offset* locked at zero.

 **Spiral Line To Element** - Creates a line with a spiral transition to another element at zero degrees skew angle; applicable only when the *To* element is a curve, *Offset* locked at zero.

 **Curve Line to Element -** Creates a line with an arc transition to another element at zero degrees skew angle; applicable only when the *To* element is a curve, *Offset* locked at zero.

 **By Angle Line to Element -** Creates a line without any transition at user defined skew angle, *Offset* locked at zero.

 **Line to Element -** Creates a line at a skew to a reference element.

 **Line From Element** – This is a series of *Line From Element* commands indicated by the arrow in the right hand corner of the icon. These pre-customized versions provide a simplified prompt sequence for many common construction tools. Right-click on the **Line From Element** icon then choose *Show/Hide Arc from Element Tools* to access the following options.

 **Simple Line From Element -** Creates a line without any transition from another element at zero degrees skew angle, Applicable only when the From Element is a curve, Offset locked at zero

 **Spiral-Line From Element -** Creates a line with a spiral transition from another element at zero degrees skew angle, applicable only when the From element is a curve, Offset locked at zero

 **Curve-Line From Element -** Creates a line with an arc transition from another element at zero degrees skew angle, applicable only when the From element is a curve, Offset locked at zero

 **By Angle Line From Element** - Creates a line without any transition from another element at a skew angle you define, Offset locked at zero

 **Line From Element** - Creates a line at a skew from a base element.

 **Line Between Arcs** - Constructs a line between two previously placed arcs. This tool has the ability to optionally apply a back and/or forward transition between the arc(s) and constructed line.

 **Chamfer Between Elements -** Planes a corner (i.e., it alters an existing intersection by inserting a line between the elements).

2.10.3 Placing Arc Geometry

 **Circle** - Creates a circular element based on the center point of the circle and a through point defining the radius.

 **Arc Between Points** - Creates an arc between points. The most common usage is Arc between 3 points, but other variations are available. Points can be defined in several ways:

- Arbitrary Data Points on the screen
- Defined using Civil AccuDraw
- Snapped relative to other elements
- An existing geometry point element

 **Simple Arc To Element** – This is a series of *Simple Arc To Element* commands indicated by the arrow in the right hand corner of the icon. These pre-customized versions provide a simplified prompt sequence for many common construction tools. Right-click on the **Simple Arc To Element** icon then choose *Show/Hide Arc to Element Tools* to access the following options.

 **Simple Arc To Element -** Constructs an arc to element with a given radius

 **2 Center Arc To Element -** Constructs an arc to element with a given radius and a back transition

 **Spiral Arc To Element -** Constructs a spiral to element

 **Reverse Spiral Arc To Element -** Constructs a Double Spiral to an element

 **Arc To Element -** Constructs an arc to element with a given radius with the addition of offset and end tangent direction

 **Simple Arc From Element** – This is a series of Simple Arc From Element commands indicated by the arrow in the right hand corner of the icon. These pre-customized versions provide a simplified prompt sequence for many common construction tools. Right-click on the **Simple Arc From Element** icon and then choose Show/Hide Arc From Element Tools to access the following options:

 **Simple Arc From Element** - Constructs an arc from an element with a given radius.

 **2 Center Arc From Element** - Constructs an arc from an element with a given radius and a back transition.

 **Spiral Arc From Element** - Constructs a spiral from an element.

 **Reverse Spiral Arc From Element** - Constructs a Double Spiral from an element.

 **Arc From Element** - Constructs an arc from an element with a given radius with the addition of offset and end tangent direction.

 **Simple Arc** – This is a series of Simple Arc commands indicated by the arrow in the right hand corner of the icon. These pre-customized versions provide a simplified prompt sequence for many common construction tools. Right-click on the **Simple Arc** icon then choose Show/Hide Arc Tools to access the following options.

 **Simple Arc** - Creates a radius arc without spirals or tapers at both ends, Offsets locked at zero

 **Spiral-Arc-Spiral** - Creates a radius arc with spiral transitions but no tapers at both ends, Offsets locked at zero

 **Taper Arc Taper** - Creates a radius arc with tapers but no transitions at both ends, Offsets locked at zero

 **3 Center Arc** - Creates a radius arc with radius transitions at both ends, result is a three centered curve, Offsets locked at zero

 **2 Center Arc** - Creates a radius arc with radius transitions at one end, result is a two centered curve, Offsets locked at zero

 **Arc Between Elements -** Constructs an arc between two previously placed elements. This tool has the ability to optionally apply a back and/or forward transition and/or taper between the elements and the constructed arc.

 **Arc Between Arcs -** Constructs an arc between two previously placed arcs. This tool has the ability to optionally apply both a back and/or forward transition between the base arcs and the constructed arc.

 **Complex Transition between any Element and Arc -** Constructs an arc between two previously placed elements. This tool has the ability to optionally apply a Back Spiral and/or Ahead Transition between the elements and the constructed arc.

2.10.4 Placing Spiral Geometry

 **Spiral From Element -** Constructs a spiral from a previously placed element, using this base element to determine tangency at one end. This tool provides chorded spirals only. Other spiral-like transitions are not supported.

 **Spiral Between Elements -** Constructs a spiral (or spirals) between two base elements that determine tangency. Dependent on the configuration of the base elements, there may be:

- Single spiral that connects: A line and an arc
- Two arcs where one arc is contained entirely within the circle of the other arc
- A compound spiral between two arcs
- A reverse spiral between two arcs

This tool provides chorded spirals only. Other spiral-like transitions are not supported.

2.10.5 Creating Complex Geometry

 **Complex By Elements -** Constructs a complex element of previously placed elements by joining them in sequence.

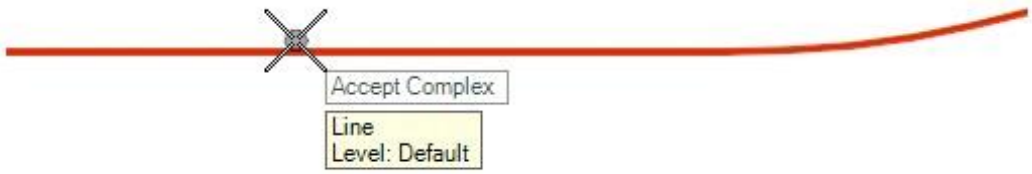
Workflow

1 . Click **Complex By Elements**. The *Complex Element* dialog displays.

There are two methods of operation: *Manual* and *Automatic*.

2. Using the *Automatic* method, hover over the beginning element until the directional arrow points to the desired direction. Left mouse-click to accept the chosen element.

3. At this point, the complex path will be highlighted. Left-click again to accept the complex creation or right-click to cancel.



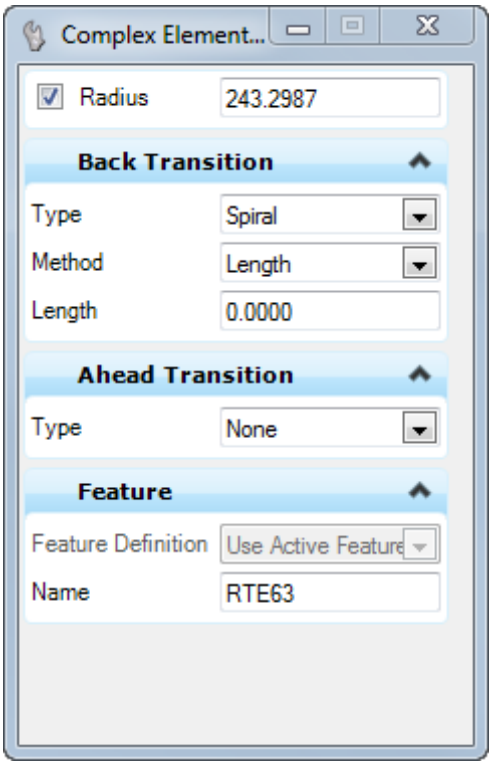
4. Alternatively, using the *Manual* method, select each element individually using the left-click.

Complex By PI - Creates a linear element with curves based on user input of PI (point of intersection) locations. The curves can include transitions or set the transitions to none.

The transitions on the curves can be arc transitions or chorded spirals using the following methods:

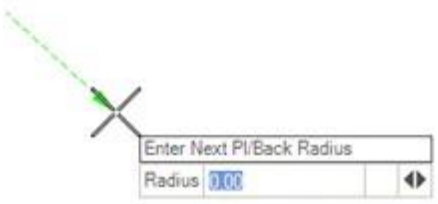
- Spiral - Length
- Spiral - A-Value
- Spiral - Deflection
- Spiral - Delta R
- Spiral - RL
- Curve - Length
- Curve - Deflection
- Curve - Delta R
- Curve - Ratio

To access these methods customize the dialog and add the method(s) of interest resulting in a customized tool.



Workflow

1. Click **Complex By PI**. The *Complex Element By PI* dialog displays.
2. Select the Civil AccuDraw favorite to be used in placement of the PIs and key-in the placement values in the heads up display or Data point to set the beginning of the element.
3. **Place the second PI**.



4. **Place the third PI**. Radius always applies to the PI prior to the one where the data point is currently being set. You can edit the radius by keying in a new value in the prompt. If the back and ahead transitions are set then this is a triple toggle input. Toggle with left-right arrow keys to set back and ahead transition parameters.
5. Continue to data point to add more PI points. Click the **Reset** button to stop adding PI points.

Start Station - Assigns stationing to an element. You assign a station value and a position along the element for that station value. This command can be used on a civil element or a plain MicroStation graphic. If this command is never run, then the beginning stationing is assumed to be zero.

Add Station Equation - Defines a station equation at a designated location on an element. If stationing has not been previously defined, then a zero starting station is also assigned. This command can be used on a civil element or a plain MicroStation graphic.

Preferences

Preferences that affect *Start Station* and *Add Station Equation* are stored as DGN settings (Settings > Design File Settings > Civil Formatting).

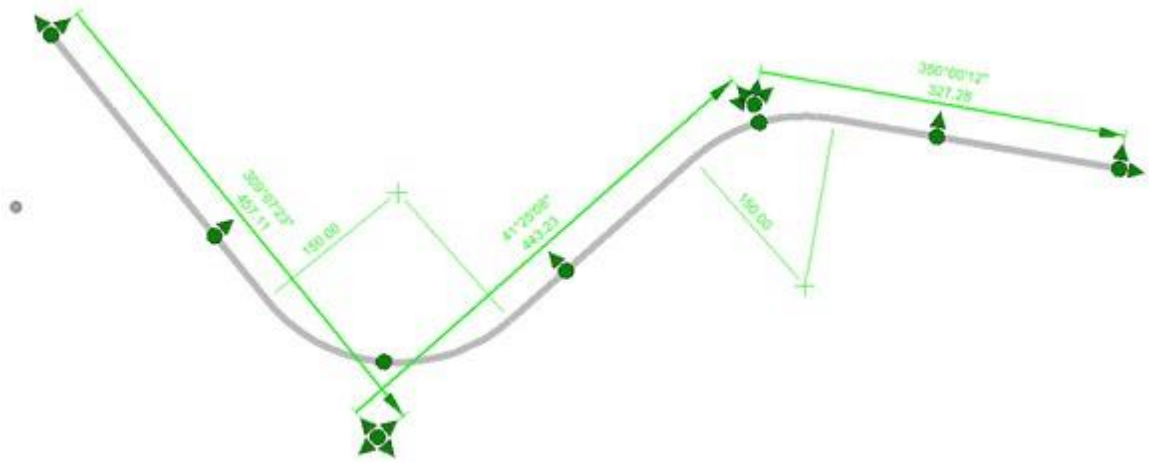
2.11 Editing Horizontal Geometry

Once a Civil Geometry Element is placed, selection of that element will display the appropriate manipulators, defining the element.

Manipulators

Manipulators are available for:

- Distance and direction on each line segment
- Radius and transition parameter on each curve
- Drag handles at PI points



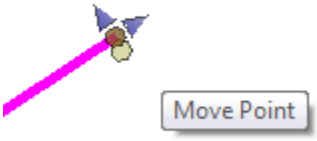
Normal Line Manipulators

When the line is placed without any snaps and without any Civil AccuDraw constraints, you will see the onscreen manipulators as shown right. These manipulators can be used to edit the line as follows:

- The distance and direction text manipulators can be clicked to allow editing of the value
- The arrows parallel to the line can be used to extend or trim the line (i.e., change the distance)
- The end point arrows perpendicular to the line can be used to rotate the line (i.e., hold the distance and change the direction)
- The perpendicular arrow at midpoint can be used to move the line parallel
- The dot at the end points can be used to move the point without constraining the distance or direction
- The dot at the midpoint can be used to move the line in its entirety

Snap Manipulator

When a line end point has been snapped, the normal manipulators are replaced by a snap manipulator. The end on the left was snapped by key point, so you see a single dot and an icon indicating the snap type.



You can move the snapped end in space by clicking the dot and dragging. This breaks the snap and creates a new endpoint location that might be a data point, a different snap or a Civil AccuDraw input.

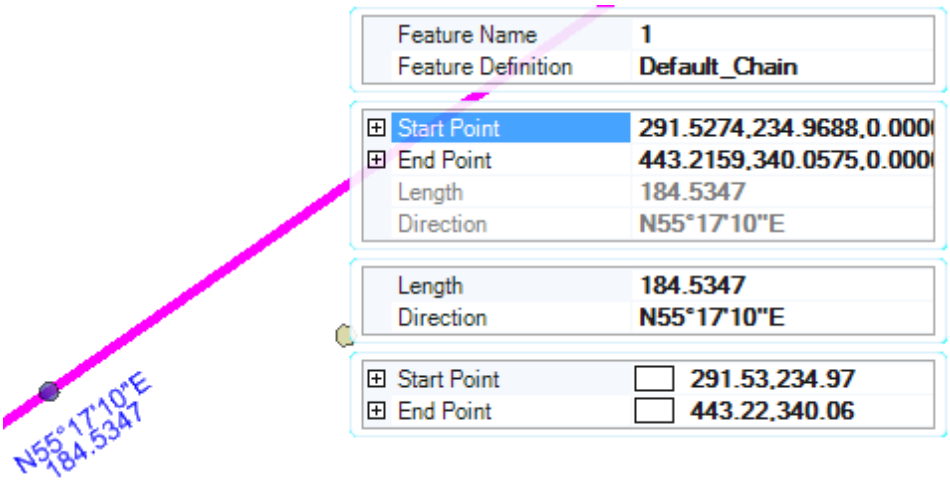
If you hover over the snapped end point dot, the normal manipulators will appear to allow extend/trim or rotate of the line. This also breaks the snap. Similarly, when a line endpoint is created by Civil AccuDraw, the normal manipulators are replaced by a single dot and the AccuDraw manipulators. The AccuDraw Manipulators are text labels that can be clicked and edited.

Hover over the dot to show the normal manipulators for rotate and trim/extend functions. This replaces the AccuDraw input with the new input values.

2.12 Horizontal Geometry Properties

The rule data is also accessible in the properties of the line. Select the line and click *Properties* from the heads up menu. Most data in the property pane can be edited to change the line definition. You can also select the geometry using the Element Selection tool and use the Element Information dialog to make changes

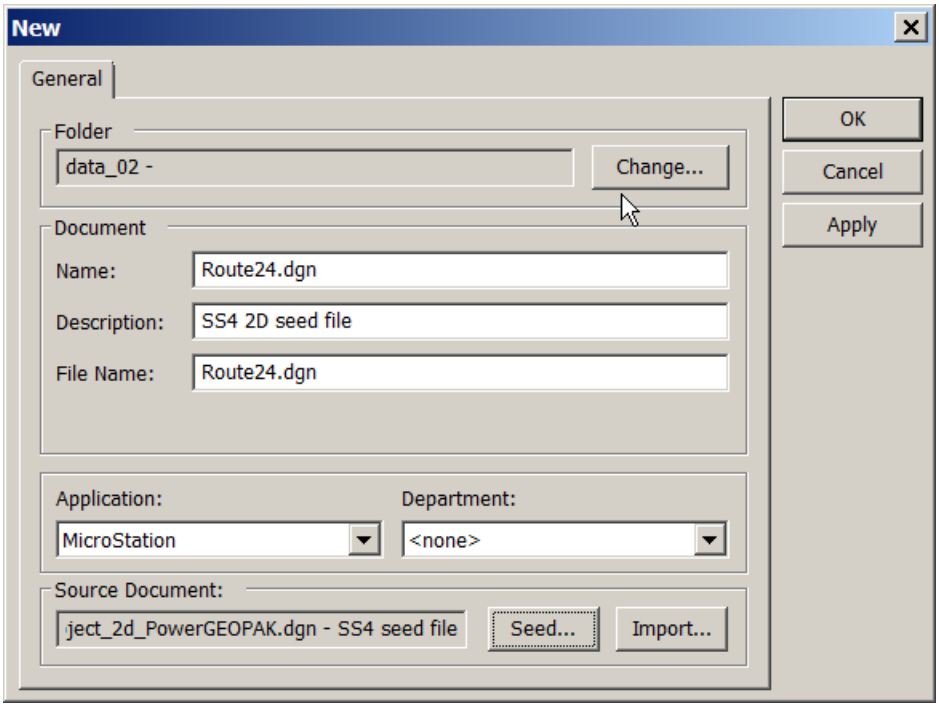
Note: When you review geometry the Element Information dialog displays the terrain models that the geometry belongs to, if any.



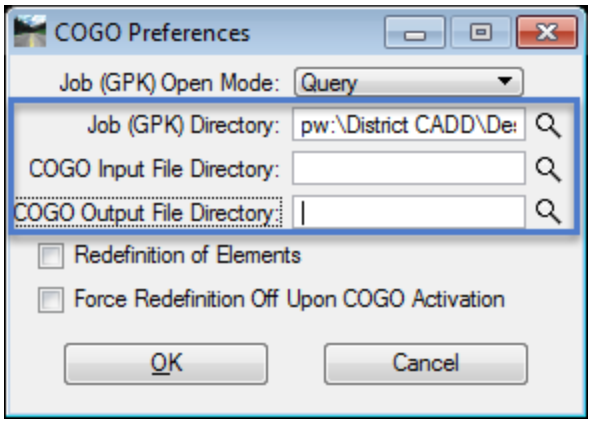
2.13 Individual Exercise 1: Route 24

1. Create a new MicroStation file named **Route24.dgn** using the

   pw:\CADD_Standards\Seed Files\Design - English\i_project_2d_PowerGEOPAK.dgn seed file from the MoDOT workspace.



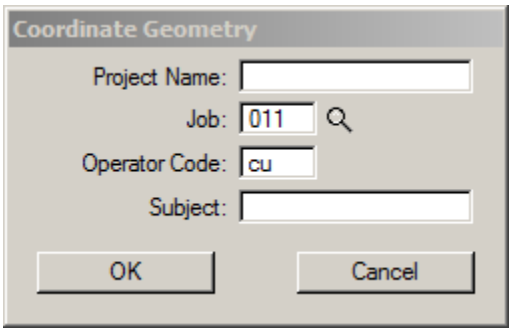
2. Go to **GEOPAK > ROAD > User Preferences**, select **COGO Preferences…** and verify the *Job (GPK) Directory*: is set to ***pw:\District CADD\Design\Randolph\J2P0200\data_02***.



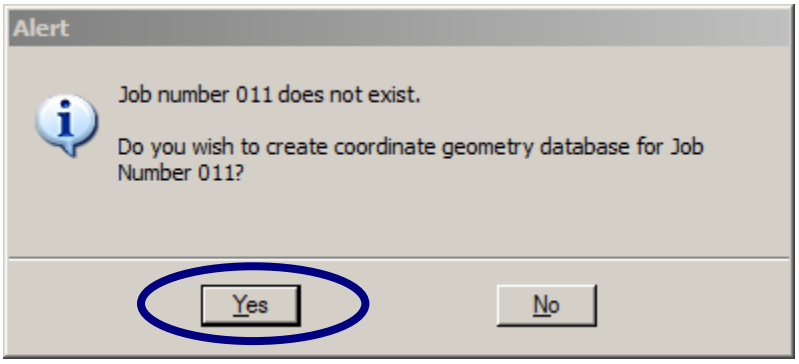
3. Click **OK** to close the *COGO Preferences* dialog.
4. Click **OK** again to close the *User Preferences* dialog.
5. Open the **Coordinate Geometry** dialog from the **GEOPAK > ROAD > Geometry** menu and enter the following values:

   Job: **011**

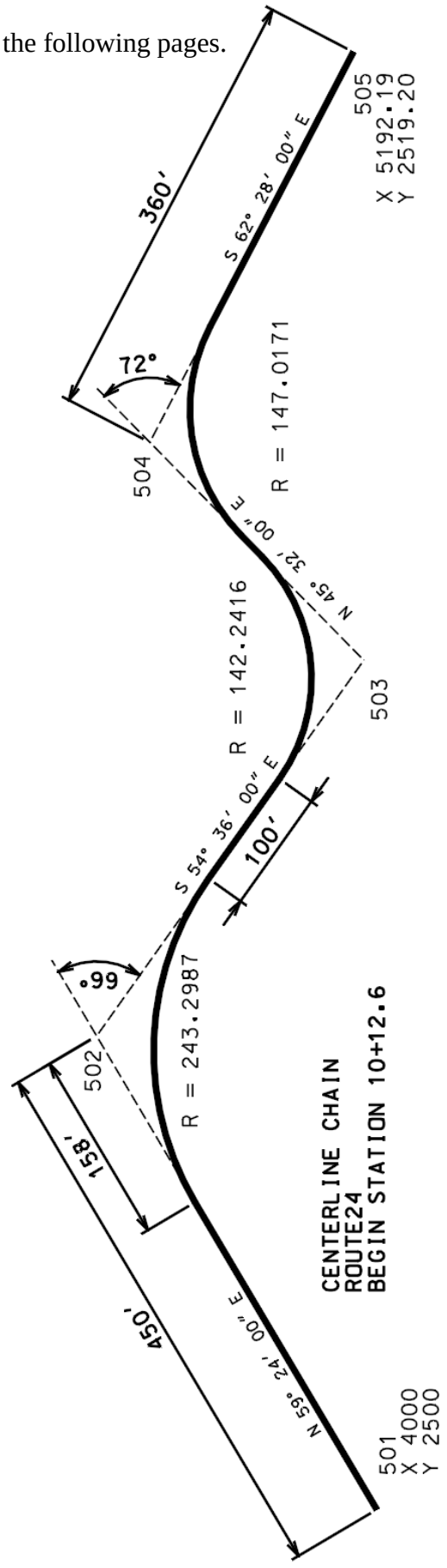
   Operator Code: **your initials**.



6. Click **OK** to dismiss the *Coordinate Geometry* dialog.
7. Since this Coordinate geometry database does not exist, you will get the following message. Select **Yes** in the *Alert* dialog to continue. The job will hold geometry in native format as the civil geometry is created.



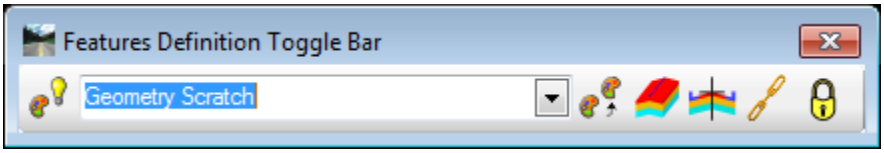
Create the alignment as shown per the step outlined on the following pages.



Creating the Tangent Elements

1. Expand the **Horizontal Geometry Toolbox** in the Tasks menu.
2.  Select **Feature Definition Toggle Bar** to open the toggle bar window.

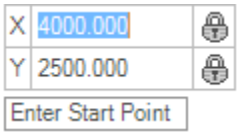
   Hint: the Feature Definition Toggle Bar can be docked at the top or bottom of the screen so it is easily accessible.
3. Set the active feature to **Design > Design Standards > Geometry> Geometry Scratch**.



4.  Enable the **Use Active Feature Definition** tool on the Feature Definition Toggle bar.

   Setting an active feature definition will cause any geometry elements created to have the active feature assigned as its Feature Definition (property).
5. Verify Civil AccuDraw is active.
6.  Select the **Line Between Points** task from the *Horizontal Geometry* task group
7. Select the **XY** favorite from the Civil AccuDraw toolbar.

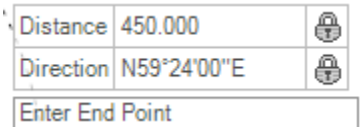
8. Using the heads up display, key in the coordinates of the first PI (501), **X = 4000 Y = 2500**.



   Hint: After locking in a value move the mouse to ensure the value is set.
9. Data point to accept the point.
10. When prompted to *Enter End Point*, make the **Distance - Direction** favorite active in Civil AccuDraw. This will change the heads display.

11. Locate the second point (502) with a *Distance* = **450** and the *Direction* = **N59°24'00.0"E**

    Hint: Directions or angles can be entered in these formats DD:MM:SS or DD^MM'SS". If Bearing is the MicroStation Definition then the Alpha indicators (N S E and W) should be entered with no spaces before the DD and after the SS.



12. Data point to accept.

13. Place another line with a Start point (505) at **X = 5192.19** and **Y = 2519.20**.

14. Define the End point (504) as *Distance* = **360** and the *Direction* = **N 62°28'00.0"W**.

15.  In Civil AccuDraw, make the **Direction - Direction** favorite active. This will find the intersection point based on two directions.

16.  Select **Line Between Points.**

17. Select the end of the first line (point 502) drawn above to make the compass active on the end point.

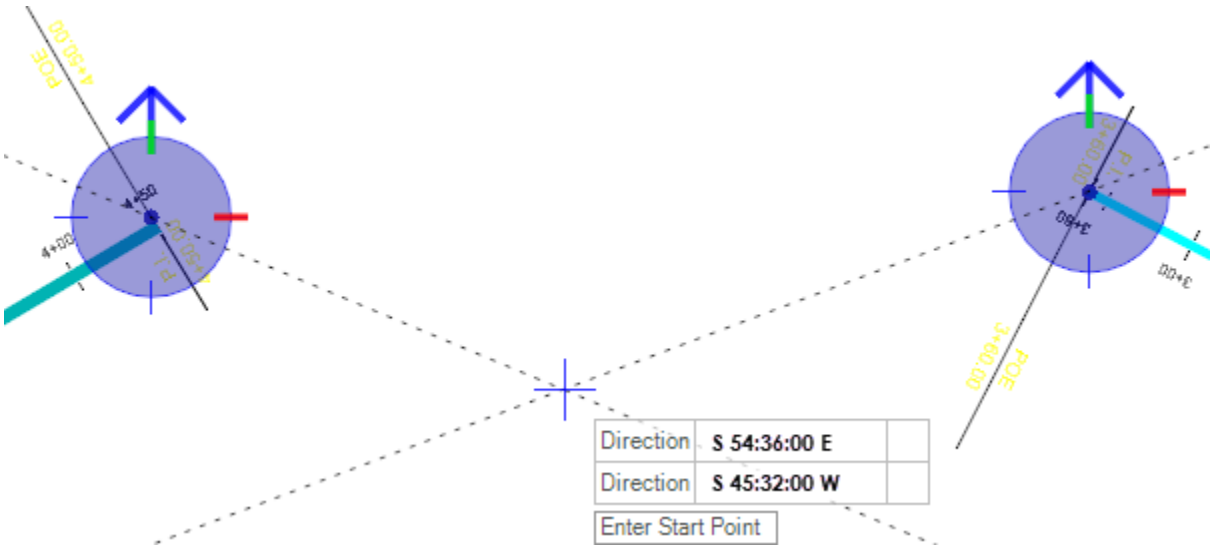
    Hint: To identify a civil Geometry object hover over it and let Civil AccuSnap select it for you

18. Enter the first direction as **S54:36:00E** and tab to the next Direction field.

19. Set the origin of the second point by typing the letter **O** and selecting the ending point of the second line (point 504).

    Note: If presented with angle instead of direction, the Civil AccuDraw compass has rotated. Key in "**T**" to rotate the compass to the top or "**V**" to rotate the compass to the View.

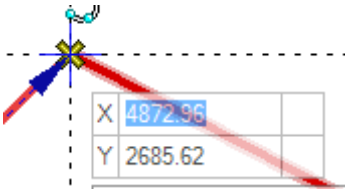
20. Enter the second direction as **S45:32:00W** and press **Tab** to view the solution.



21. Data point in the view to accept the solution and place the line.

22.  Select **Line Between Points.**

23. AccuSnap to the end points of the first line placed (at 502) and second line placed (at point 504).



This completes the placement of the tangent sections. The curves for Route24 will be placed using the ***Simple Arc*** command.

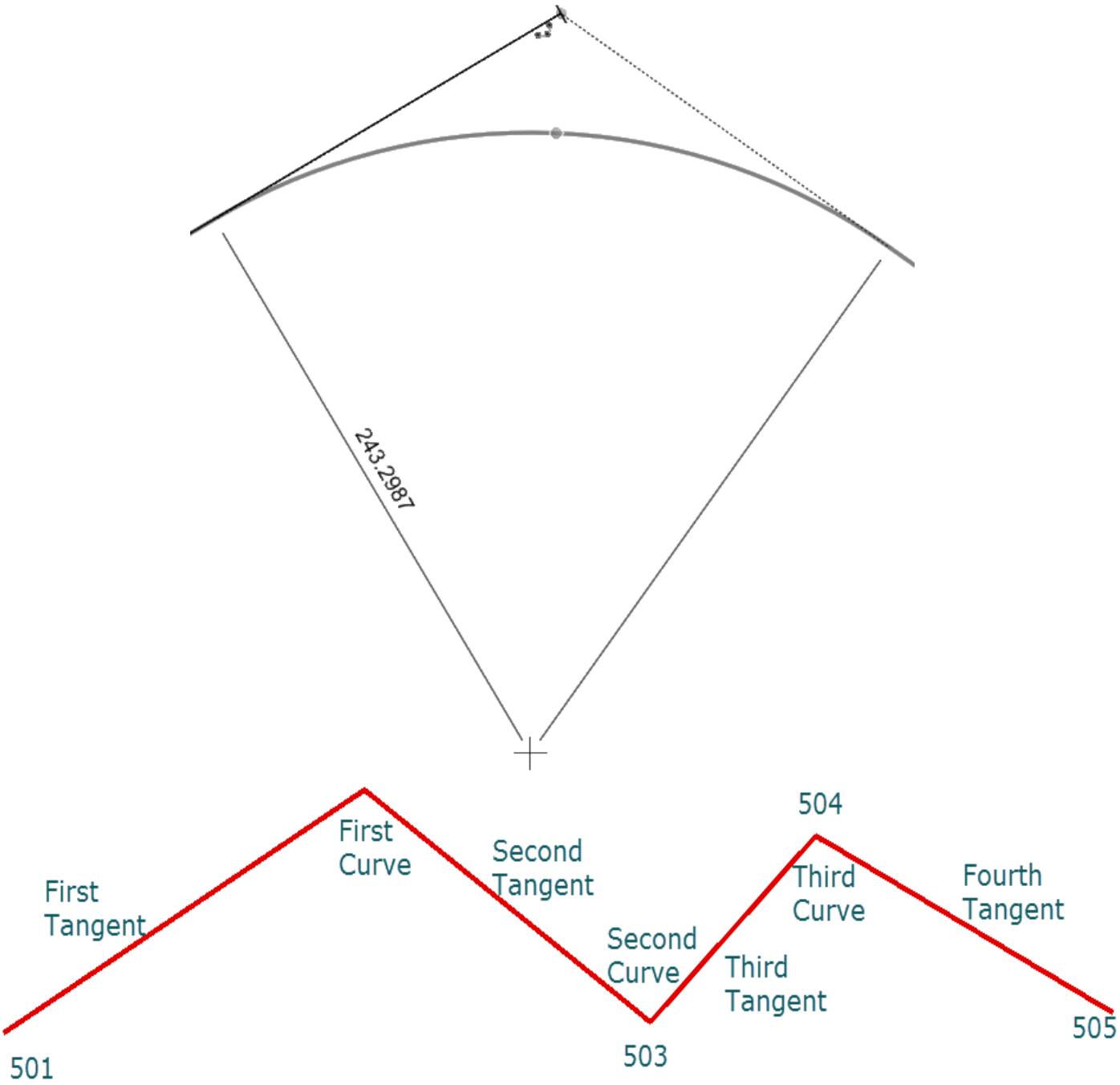
Placing the Curves

24. **Turn off** Civil AccuDraw

25.  Select **Simple Arc.**

26. Set the *Trim/Extend* option to **Both** and left-click twice to accept the solution.

27. Enter the **243.2987** as the *Radius* for the first curve.



28. When prompted to *Locate First Element*, select the first tangent as noted in the graphic above then select the second tangent.

29. **Data Point** to accept the arc location. **Data Point** again to accept the Truncate Option.
30. Repeat steps 2-6 for the second curve with a Degree of Curve using Second and Third Tangents shown above. Second Curve **Radius is 142.2416**.
31. Repeat steps 2-6 for the third curve using Third and Fourth Tangents shown above. Third Curve **Radius is 147.0171**.

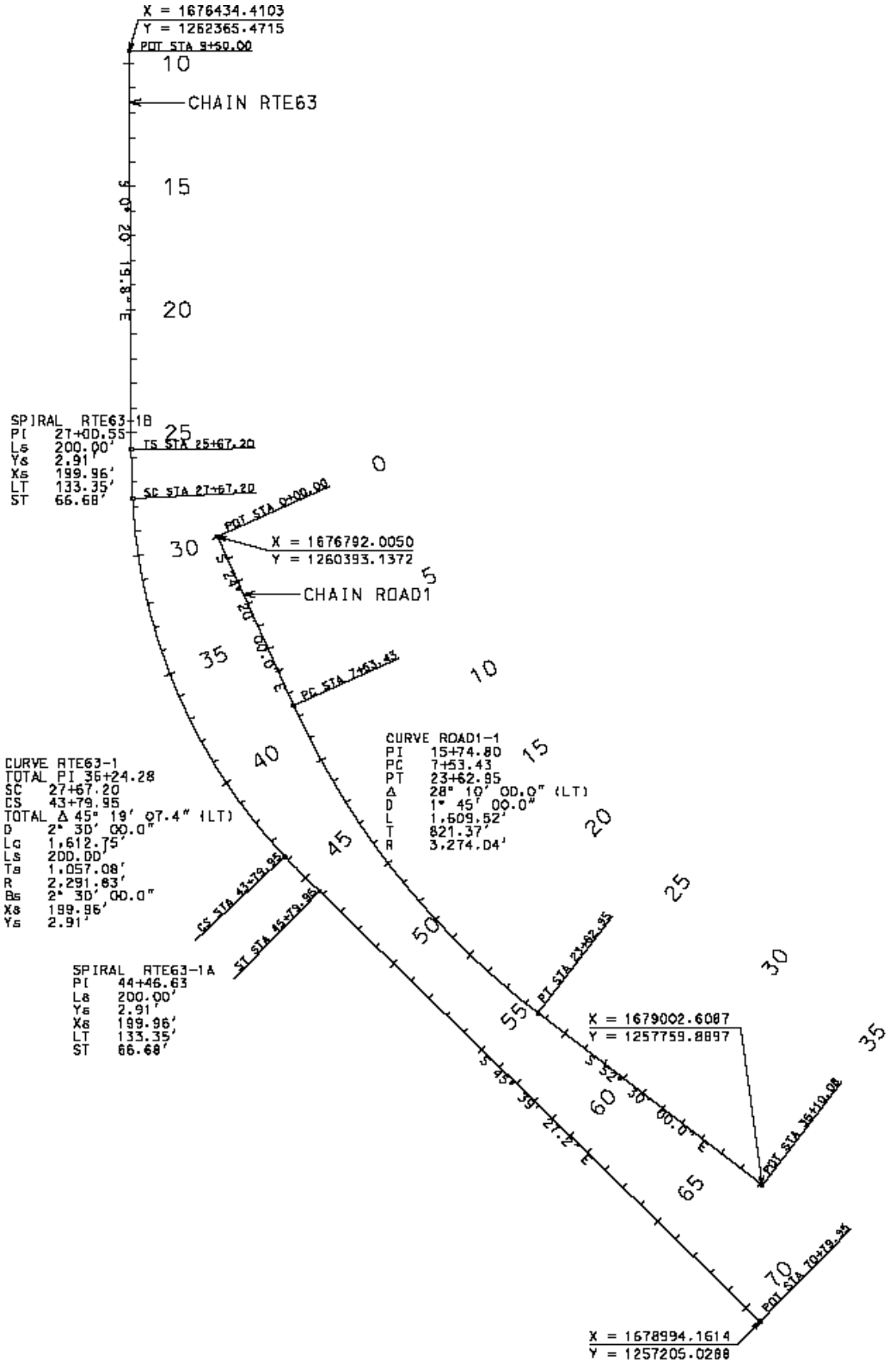
Complex the Elements into one Chain

32.  Select the **Complex by Elements** task.
33. Set the active feature to **Design > Drafting Standards > Plan > Alignments > MoDOT_Baseline_Proposed**.
34. Set the *Method* to **Automatic**.
35. Key in **Route24** in the *Name* field.
36. When prompted to *Locate First Element*, identify the beginning of the first linear element placed. **Note**: The Arrow indicates the direction the chain will be processed.
37. If presented with the *Job Number* dialog, select **job011.gpk** and select **OK**.

Set the beginning stationing

38.  Select the **Start Station**.
39. When prompted to *Locate Element*, select the Route24 alignment.
40. Set the *Start Distance* to **0**. **Data Point** to accept.
41. Enter **10+12.6** as the *Start Station*. The station can be modified in the *Element Information* dialog.
42. Verify the label for the start station has been changed to *POT STA 10+12.60*.
43. Select **File > Update Server Copy**.

2.14 Group Exercise 2: Road 1 Alignment



Create a new MicroStation file: **Civil_Geometry_ J2P0200.dgn**.

1. Click **Seed** and select ***pw:\CADD_Standards\Seed Files\Design - English\i_project_2d_PowerGEOPAK.dgn*** as the seed file
2. Save the new file to the following location:

   Randolph\data_02\Civil_Geometry_ J2P0200.dgn.

   Note: You may need to *Check In* Route24.dgn when creating the new file
3. Reference the existing Terrain model by selecting Reference **File > Tools > Attach**. Select **Terrain_J2P0200_Existing.dgn** and set the attachment method as Coincident World.
4. Click **OK**. Dismiss the Reference file dialog.
5. Select Fit View.
6. Create a new GPK using job number **200** and save it to ProjectWise as job200.gpk.

Use the *Civil Geometry* tools and follow the steps below to create the alignments as shown on the previous page.

Road1

Beginning Point: X = **1,676,792.0050** Y = **1,260,393.1372**
Ending Point: X = **1,679,002.6087** Y = **1,257,759.8897**

Beginning station of **Road1** is **0+00.00**.

Curve Data

Direction Back = **S 24° 20’ 00.0” E**
Degree of Curve = **1° 45’ 00”**
Direction Ahead = **S 52° 30’ 00.0” E**

7. Set the active feature to:

   Design > Design Standards > Geometry > Geometry Scratch.
8. Toggle **On** *Use Active Feature Definition*.
9. Toggle **Civil AccuDraw** to **active**.
10. Pin the **Task Menu** and expand the **Horizontal Geometry Toolbox**.
11. Use the “**Line Between Points**” tool along with **Civil AccuDraw** to place two lines that represent the two tangent sections of the Road1 alignment. Make sure these two lines are long enough so that they overlap each other. What we are attempting to do is locate the

overall PI location of the Spiral-Curve-Spiral using the intersection of the two Civil Geometry Lines.

a. Select the "**Line Between Points**" tool, and using **Civil AccuDraw** and it's **XY** function, key in the coordinates X = **1,676,792.0050,** Y = **1,260,393.1372**

b. Once the start of the alignment has been defined, continue to place the line using **Civil AccuDraw** and its **Distance-Direction** option at a bearing of **S 24° 20' 00.0" E** at a length that would extend past the PI location of the Curve (a length of at least 1,750 feet will work). When typing in a bearing use a colon "**:**" in-between the **Degrees:Minutes** and **Minutes:Seconds**. For this step you would type **S24:20E**

Note: If "**Angle**" is display instead of "**Bearing**" in the Civil AccuDraw heads-up display select the keyboard keys "**R**" and then "**T**". This is a Civil AccuDraw shortcut to **R**otate the compass to the **T**op view.

c. Select the "**Line Between Points**" tool, and using **Civil AccuDraw** and it's **XY** function, key in the coordinates X = **1,679,002.6087**, Y = **1,257,759.8897**

d. Once the end of the alignment has been defined, continue to place the line using **Civil AccuDraw** and its **Distance-Direction** option at a bearing of **N 52° 30' 00.0" W** at a length that would extend past the PI location of the Curve (a length of at least 2,500 feet will work). When typing in a bearing use a colon "**:**" in-between the **Degrees:Minutes** and **Minutes:Seconds**. For this step you would type **N52:30W.**

Note: If "**Angle**" is display instead of "**Bearing**" in the Civil AccuDraw heads-up display select the keyboard keys "**R**" and then "**T**". This is a Civil AccuDraw shortcut to **R**otate the compass to the **T**op view.

12. Deactivate **Civil AccuDraw**.

13. Next store the **Curve** by selecting the **Simple-Arc** tool, and defining the tool with the following parameters:

    Degree of Curve = **1° 45' 00"**

    Notes:

    - To switch from **Radius** to **Degree of Curve** or vise-versa type in a "**d**" in the Radius field and then add the degree of curve value.
    - When typing in a Degree of Curve use a colon "**:**" and place in-between the **Degrees:Minutes** and **Minutes:Seconds**. For this example you would type **d 1:45:00** or **d 1:45** for short.

    Once the tool is defined with the correct parameters select each tangent and place the Spiral-Curve-Spiral trimming both tangents back.

14. Select **Create Complex Element** and to turn the individual element into one complex element. Name the complex element "**Road1**" with no spaces. Make sure the stationing will be flowing (getting larger) in a southerly direction.

15. Using the "**Start Station**" tool set the *Beginning Station* to **0+00.00**.

16. Make sure the MicroStation Drawing Scale is set to **1"=50'**.

17. Set the active feature to **Design > Drafting Standards > Plan > Alignments > MoDOT Baseline Proposed**.
    a. IF prompted select the **200** gpk.
18. Generate a **Horizontal Geometry Report** by "left clicking" on the alignment and selecting from the heads up menu the **Horizontal Geometry Report** Tool.
    a. Verify in the Report that the geometry is correct.
19. Select **File > Update Server Copy**.

2.15 Individual Exercise 3: Route63 Alignment

Route 63

Beginning Point: X = **1,676,434.4103** Y = **1,262,365.4715**
Ending Point: X = **1,678,994.1614** Y = **1,257,205.0288**

Beginning station of **RTE63** is **9+50.00**.

Spiral-Arc-Spiral Information

Direction Back	= **S 0° 20' 19.8" E**
Length of the back spiral	= **200'**
Degree of Curve	= **2° 30' 00"**
Length of the ahead spiral	= **200'**
Direction Ahead	= **S 45° 39' 27.2" E**

1. Set the active feature to:

   Design > Drafting Standards > Geometry > Geometry Scratch.

2. Toggle **On** *Use Active Feature Definition*.

3. Toggle **Civil AccuDraw** to **active**.

4. Pin the **Task Menu** and expand the **Horizontal Geometry Toolbox**.

5. Use the "**Line Between Points**" tool along with **Civil AccuDraw** to place two lines that represent the two tangent sections of the Route 63 alignment. Make sure these two lines are long enough so that they overlap each other. What we are attempting to do is locate the overall PI location of the Spiral-Curve-Spiral using the intersection of the two Civil Geometry Lines.

   a. Select the "**Line Between Points**" tool, and using **Civil AccuDraw** and it's **XY** function, key in the coordinates X = **1,676,434.4103**, Y = **1,262,365.4715**

   b. Once the start of the alignment has been defined, continue to place the line using **Civil AccuDraw** and its **Distance-Direction** option at a bearing of **S 0° 20' 19.8" E** at a length that would extend past the Overall PI location of the Spiral-Curve-Spiral (a length of at least 4,000 feet will work). When typing in a bearing use a colon "**:**" in-between the **Degrees:Minutes** and **Minutes:Seconds**. For this step you would type **S0:20:19.8E**

   Note: If "**Angle**" is display instead of "**Bearing**" in the Civil AccuDraw heads-up display select the keyboard keys "**R**" and then "**T**". This is a Civil AccuDraw shortcut to **R**otate the compass to the **T**op view.

c. Select the "**Line Between Points**" tool, and using **Civil AccuDraw** and it's **XY** function, key in the coordinates **1,678,994.1614** Y = **1,257,205.0288**

d. Once the end of the alignment has been defined, continue to place the line using **Civil AccuDraw** and its **Distance-Direction** option at a bearing of **N 45° 39' 27.2" W** at a length that would extend past the Overall PI location of the Spiral-Curve-Spiral (a length of at least 4,000 feet will work). When typing in a bearing use a colon "**:**" in-between the **Degrees:Minutes** and **Minutes:Seconds**. For this step you would type **N45:39:27.2W**

Note: If "**Angle**" is display instead of "**Bearing**" in the Civil AccuDraw heads-up display select the keyboard keys "**R**" and then "**T**". This is a Civil AccuDraw shortcut to **R**otate the compass to the **T**op view.

6. Deactivate **Civil AccuDraw**.

7. Next store the **Spiral-Arc-Spiral** by selecting the **Spiral-Arc-Spiral** tool, and defining the tool with the following parameters:

Length of the back spiral	= **200'**
Degree of Curve	= **2° 30' 00"**
Length of the ahead spiral	= **200'**

Notes:

- To switch from **Radius** to **Degree of Curve** or vise-versa type in a "**d**" in the Radius field and then the degree of curve value.
- When typing in a Degree of Curve use a colon "**:**" and place in-between the **Degrees:Minutes** and **Minutes:Seconds**. For this example you would type **d 2:30:00** or **d 2:30** for short.

Once the tool is defined with the correct parameters select each tangent and place the Spiral-Curve-Spiral trimming both tangents back.

8. Select **Create Complex Element** and to turn the individual element into one complex element. Name the complex element "**Route63**" with no spaces. Make sure the stationing will be flowing (getting larger) in a southerly direction.

a. IF prompted select the **200** gpk.

9. Using the "**Start Station**" tool set the *Beginning Station* to **9+50.00**.

10. Make sure the MicroStation Drawing Scale is set to **1"=50'**.

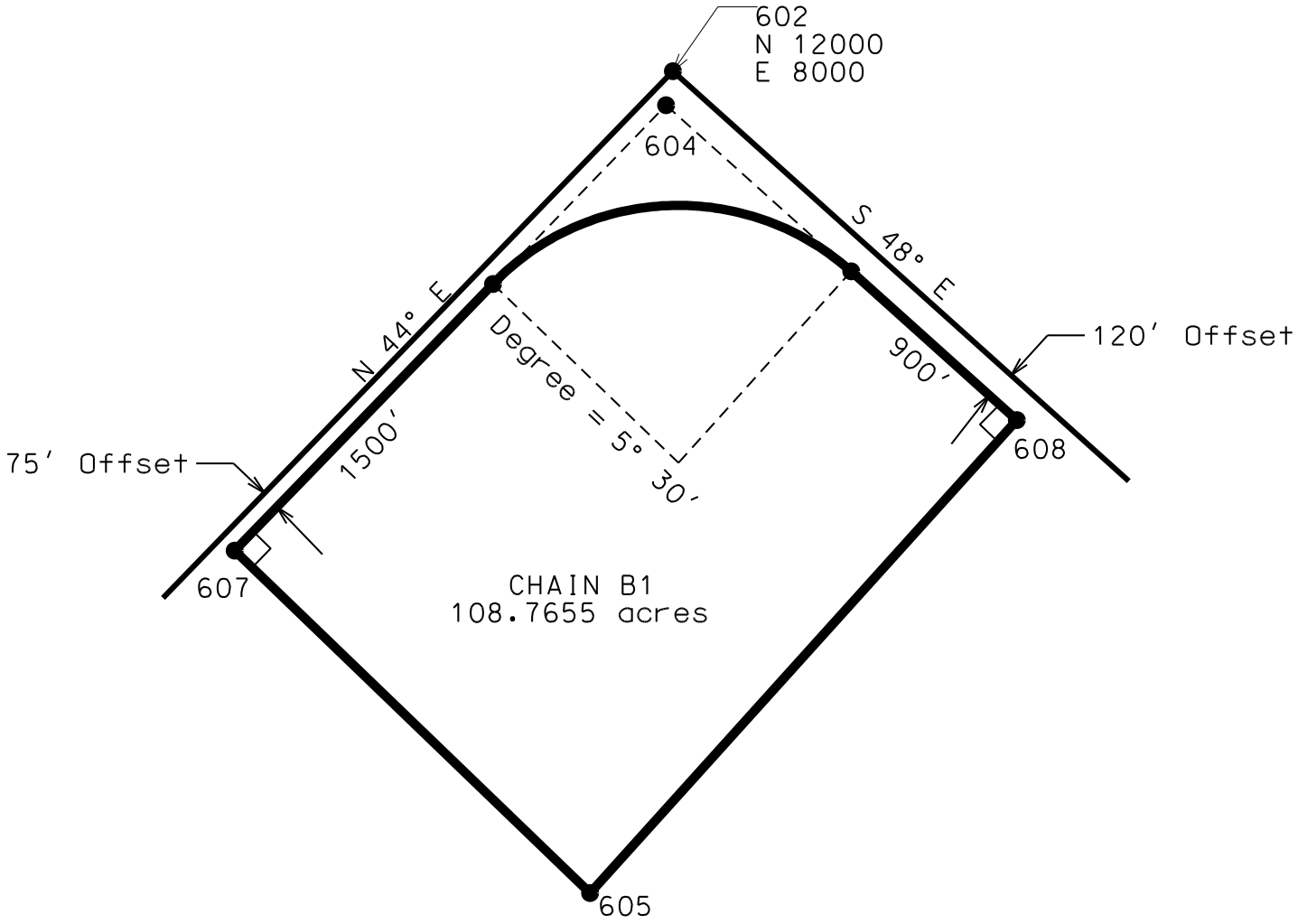
11. Set the active feature to **Design > Drafting Standards > Plan > Alignments > MoDOT Baseline Proposed**.

a. IF prompted select the **200** gpk.

12. Generate a **Horizontal Geometry Report** by “left clicking” on the alignment and selecting from the heads up menu the **Horizontal Geometry Report** Tool.
    a. Using the report verify the Beginning and Ending coordinates are correct to 4 decimal places.
13. Select **File > Update Server Copy**.

2.16 Individual Exercise 3 (Optional): B1

1. Create a new MicroStation file named **B1.dgn**
2. Use the **Civil Geometry** tools to create chain B1 as shown below. Verify the area of the chain.



Hints:

- Angles at 604 and 605 are not 90°
- The tanget lengths of 1,500 and 900 are distances from the point of Curvature.

  Store as a Complex Linear Element and verify the area by "left clicking" on the new alignment and selecting from the heads up menu the **Horizontal Geometry Report** tool. Use a report called **Horizontal Alignment Area** to get the area of the alignment.