



# **Kansas Department of Transportation**

## **Horizontal Curve Tool**

User Guide (FINAL)

Prepared by:

URS Corporation  
1333 Broadway, Suite 800  
Oakland, CA 94612

December 22, 2014



---

**CONTENTS**

---

<b>List of Figures</b>	<b>iii</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Summary of Curve-detection Tool	1
<b>2 General Workflow</b>	<b>3</b>
<b>3 Parameter Description</b>	<b>7</b>
3.1 Input Roads	7
3.2 Workspace	8
3.3 Unique ID (Name Fields)	9
3.4 Perform Topology Check	10
3.5 Simplify Line Tolerance	11
3.6 Change in Bearing Threshold	12
3.7 Maximum Distance	13
3.8 Output Observed Curve Lines (Feature Class)	14
3.9 Output Best-Fit Curves (Feature Class)	15
3.10 Angle Resolution for Best-Fit Curves	16
<b>Figures</b>	<b>17</b>



---

## LIST OF FIGURES

---

Figure 1. Observed versus best-fit curve and angle resolution for resulting feature class .....	18
---	----



---

## 1 INTRODUCTION

---

The Kansas Department of Transportation (KDOT) requires a GIS-based tool that will estimate the parameters of the best-fit circle to recorded points on horizontal circular curves. The estimated parameters may be used as inputs to perform safety evaluations and to provide information for road improvement projects.

KDOT has elicited the support of URS Corporation (URS) to create an ArcGIS 10.2 Python tool to support this analysis on Kansas current road systems. This document comprises the user guide for the contracted GIS tool.

This guide is composed of snapshots of each individual parameter from the tool's graphical user interface (GUI).

### 1.1 Summary of Curve-detection Tool

The primary objective of this tool is to estimate the parameters of a best-fit circle to recorded points on horizontal circular curves. This tool is designed to estimate the center and the radius of the best-fit circle using the Hyperfit<sup>1</sup> algorithm to the road data from horizontal, circular curves.

The input parameter “Perform topology check” is now an option that implements the rule “Must be Single Part” to remove roads that have a multi-part topology. Analysis of the later-submitted KDOT road test data indicated that this topological problem was not an issue, and had no effect on the curve detection process. However, it is recommended that this option be used if the curve-detection process produces unexpected results.

---

<sup>1</sup> Al-Sharadqah, A. and N. Chernov. 2009. Error Analysis for circle fitting algorithms. Elec. J. Stat. 3 886–911.



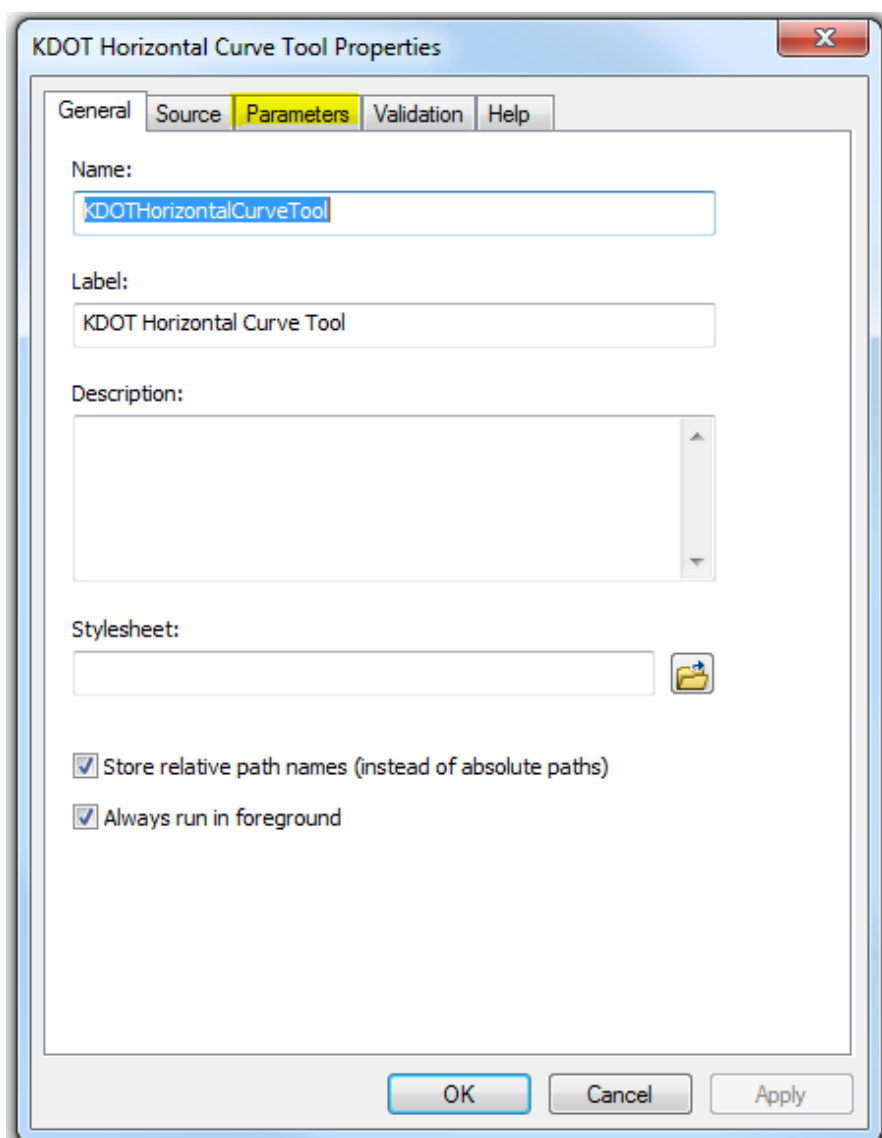


## 2 GENERAL WORKFLOW

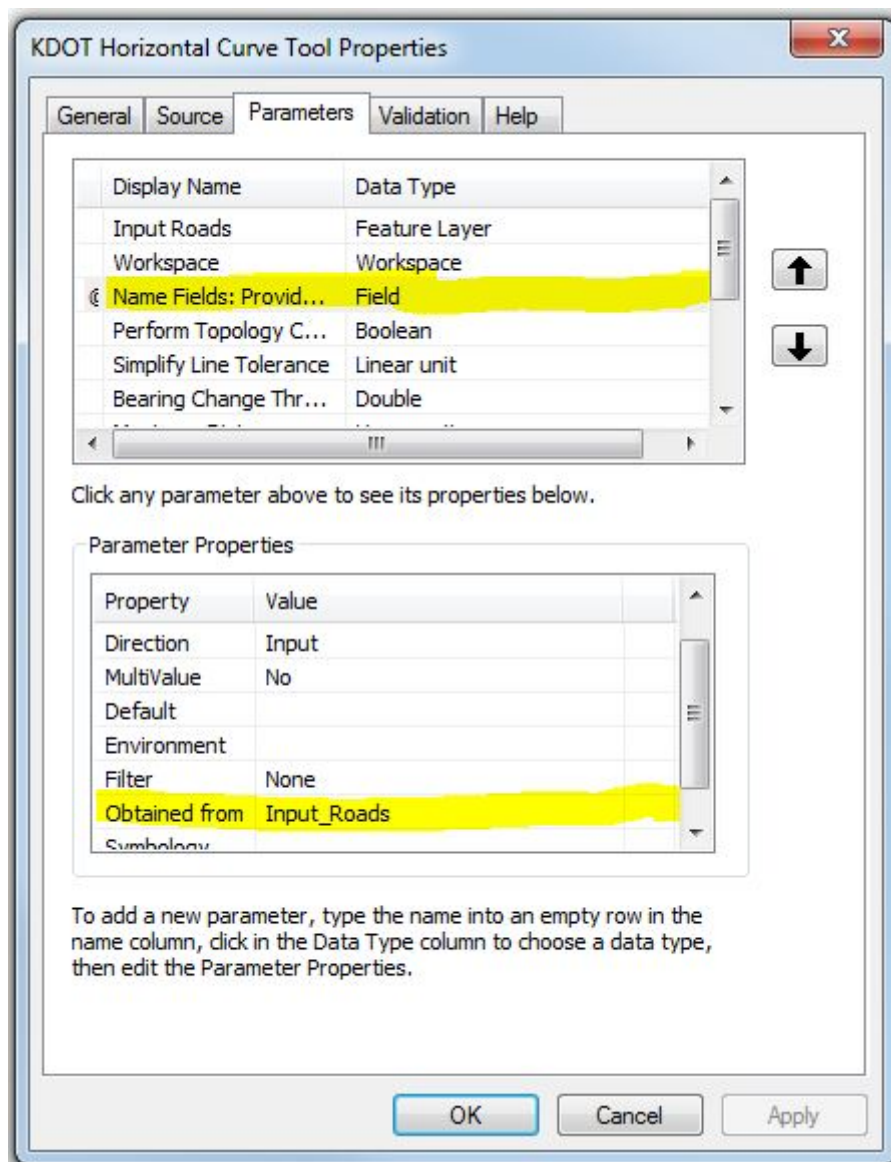
This tool must be run using ArcGIS Intermediate or Advanced Version 10.2. The tool will not run under the ArcGIS Basic license.

The tool has been delivered within a file geodatabase. No installation of the tool is required – simply open ArcMap and use the ArcCatalog window to browse to the file geodatabase delivered from URS. Expand the file geodatabase and locate the “KDOT Horizontal Curve Tool” toolbox. The script tool will be shown within and is called “KDOT Horizontal Curve Tool.”

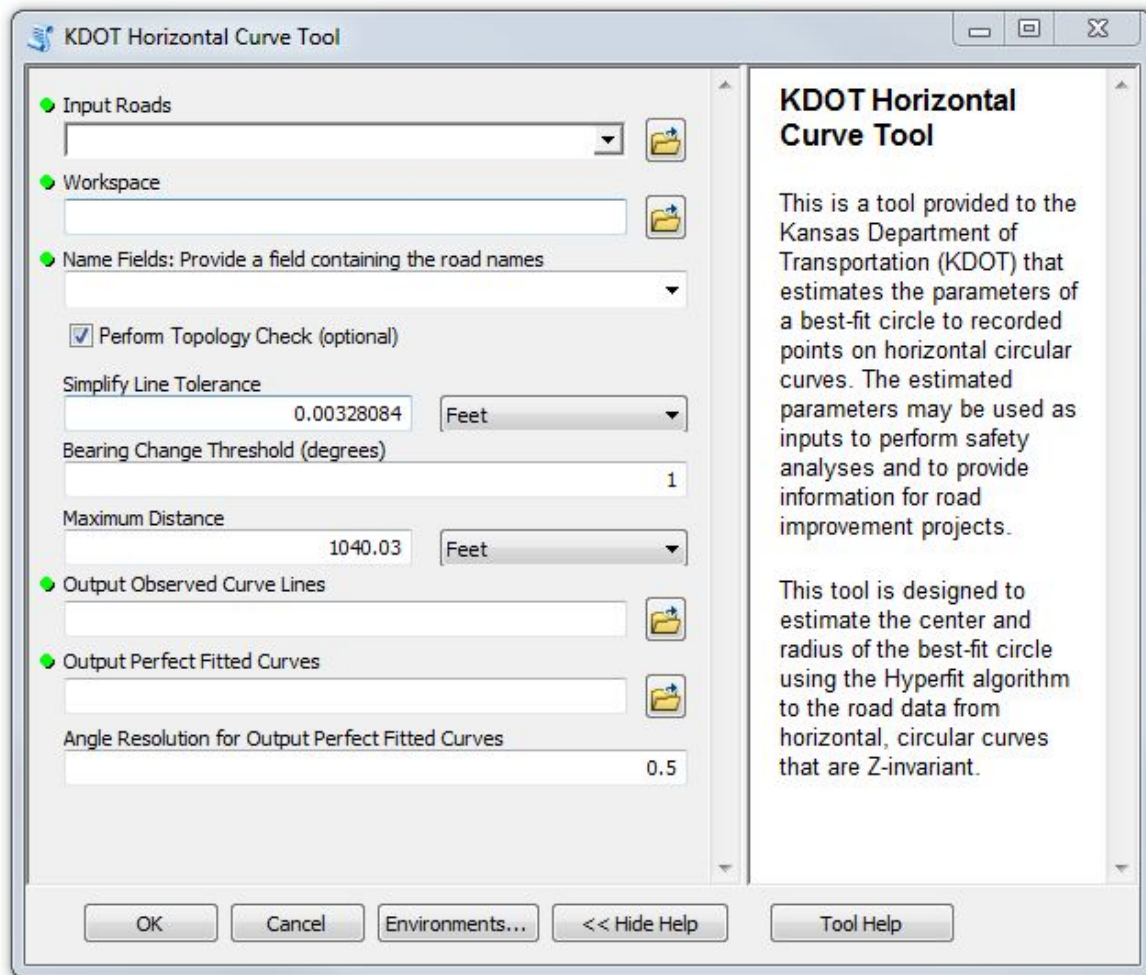
Due to a potential bug in ArcGIS 10.2, occasionally the tool parameter settings may not transfer properly when the toolbox is moved between machines. Consequently, the configuration of the “Name Fields: Provide a field containing the road names” parameter must be confirmed. To do this, right click on the “KDOT Horizontal Curve Tool” geoprocessing script and click “Properties...”. The following window will open. Click on the “Parameters” tab:



Under the “Parameters” tab, click on the “Name Fields: Provide a field containing the road names” parameter. In the “Parameter Properties” sub-section, ensure that the “Obtained from” field is set to “Input\_Roads.” Then, click OK.



To run the tool, return to the “KDOT Horizontal Curve Tool” toolbox, and double-click on the “KDOT Horizontal Curve Tool” geoprocessing script. The following window will open.



A total of ten parameters are required for the tool to run successfully. All ten parameters must be entered, and none may be left blank. A detailed description of each individual parameter follows.



### 3 PARAMETER DESCRIPTION

The following sub-sections describe the ten parameters required to be entered for the tool.

#### 3.1 Input Roads

**KDOT Horizontal Curve Tool**

**Input Roads**

CRND

Workspace  
\\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\01

Name Fields: Provide a field containing the road names  
NE\_UNIQUE

☒ Perform Topology Check (optional)

Simplify Line Tolerance  
0.00328084 Feet

Bearing Change Threshold (degrees)  
1

Maximum Distance  
1040.03 Feet

Output Observed Curve Lines  
\\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\01

Output Perfect Fitted Curves  
\\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\01

Angle Resolution for Output Perfect Fitted Curves  
0.5

**Input Roads**

This is an input PolylineM feature class comprising a roads layer. These features must be contained within a file geodatabase.

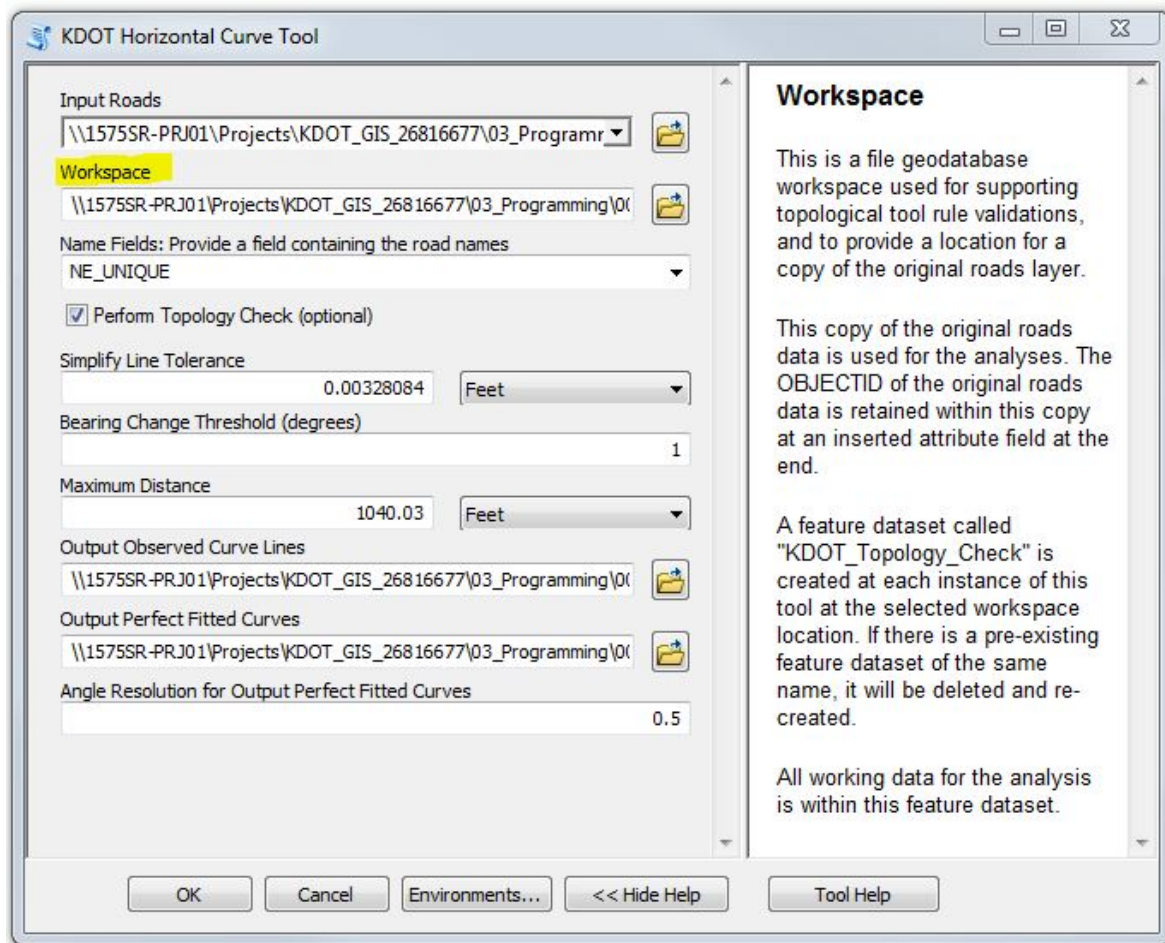
**Currently, this must be referenced as a layer within the active arcmap data frame.**

This MUST be a SINGLE-PART feature class. Any multi-part features will be rejected for analysis.

OK Cancel Environments... << Hide Help Tool Help

This is an input PolylineM feature class comprising a roads layer. **This MUST exist as a layer within the current ArcMap session.** These features must be contained within a file geodatabase. It is recommended that this **should** be a **single-part** feature class. Any multi-part features will be rejected for analysis if the parameter “Perform Topology Check (optional)” is selected.

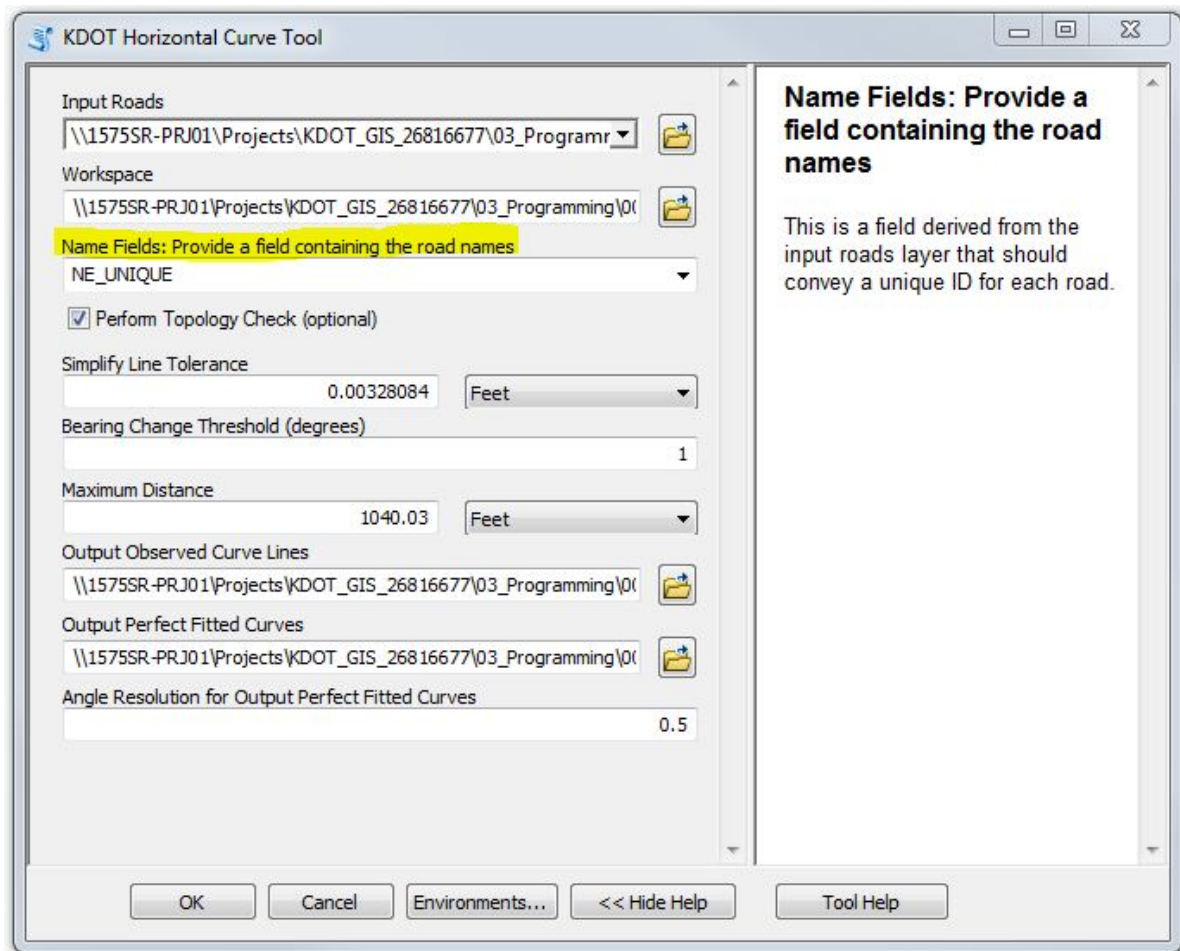
## 3.2 Workspace



This is a file geodatabase workspace used for supporting topological tool rule validations, and to provide a location for a copy of the original roads layer. This copy of the original roads data is stored for the analysis within this location, and the original roads data set is untouched. The OBJECTID of the original roads data is retained within this copy at an inserted attribute field at the end. A feature data set called "KDOT\_Topology\_Check" is created at each instance of this tool at the selected workspace location. If there is a pre-existing feature data set of the same name, it will be deleted and re-created.



### 3.3 Unique ID (Name Fields)



**KDOT Horizontal Curve Tool**

Input Roads  
\\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programr

Workspace  
\\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\01

**Name Fields: Provide a field containing the road names**  
NE\_UNIQUE

☒ Perform Topology Check (optional)

Simplify Line Tolerance  
0.00328084 Feet

Bearing Change Threshold (degrees)  
1

Maximum Distance  
1040.03 Feet

Output Observed Curve Lines  
\\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\01

Output Perfect Fitted Curves  
\\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\01

Angle Resolution for Output Perfect Fitted Curves  
0.5

**Name Fields: Provide a field containing the road names**  
This is a field derived from the input roads layer that should convey a unique ID for each road.

OK Cancel Environments... << Hide Help Tool Help

This is a fields derived from the input roads layer. The user must select one of these fields that should convey a unique ID for each road.

### 3.4 Perform Topology Check

**KDOT Horizontal Curve Tool**

Input Roads: CRND

Workspace: \\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\00\_Python\00\_Scripts\KDOT\_HorizontalC

Name Fields: Provide a field containing the road names  
NE\_UNIQUE

☒ Perform Topology Check (optional)

Simplify Line Tolerance: 0.00328084 Feet

Bearing Change Threshold (degrees): 1

Maximum Distance: 1040.03 Feet

Output Observed Curve Lines: \\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\00\_Python\00\_Scripts\KDOT\_HorizontalC

Output Perfect Fitted Curves: \\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\00\_Python\00\_Scripts\KDOT\_HorizontalC

Angle Resolution for Output Perfect Fitted Curves: 0.5

**Perform Topology Check (optional)**

This institutes the topology validation rule **"Must Be Single Part"**, and is optional.

Any roads that are MULTIPART will be ignored for the analysis if this option is selected.

A copy of the input roads is deposited into the feature dataset "KDOT\_Topology\_Check" and identified by concatenating "\_check" after the input feature class name.

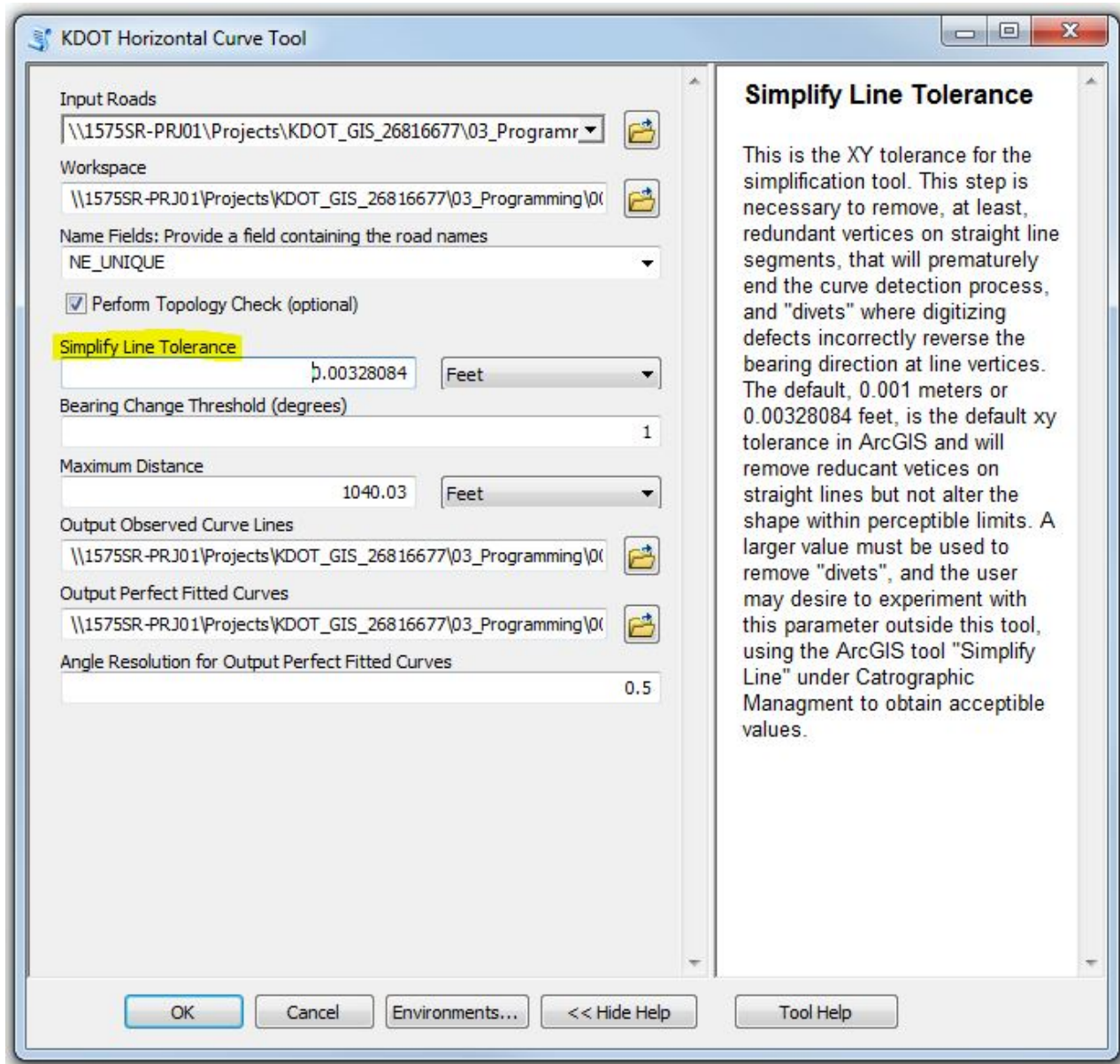
Any features that do not conform to the topology rule are written out to feature classes identified by concatenating "\_point", "\_line", and "\_poly" after the input feature class name. Thus, an input feature class named "Roads" will at least produce a copy called "Roads\_check", and, if the topology check is selected, generate 3 new features classes called "Roads\_point", "Roads\_line" and "Roads\_polygon" that identify the topology errors.

OK Cancel Environments... << Hide Help Tool Help

This institutes the topology validation rule **"Must Be Single Part."** Any roads that are **multipart** will be ignored for the analysis if this parameter is selected. The tool performance for roads that are multipart lines is not warranted.



### 3.5 Simplify Line Tolerance



This applies the tool "Simplify Line" to the input roads layer. This process uses the rule "POINT\_REMOVE." The simplification removes small perturbations in the line from digitization errors that will cause a premature end to curve detection. This is the actual parameter in the XY tolerance for the simplification tool. The user may desire to experiment externally with the "simplify line" tool in ArcGIS to determine the most effective value. The default simplification of 0.00328084 feet or 0.001 meters will **always** be run to eliminate redundant vertices on straight line segments.

### 3.6 Change in Bearing Threshold

**KDOT Horizontal Curve Tool**

Input Roads  
\\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programr

Workspace  
\\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\01

Name Fields: Provide a field containing the road names  
NE\_UNIQUE

☒ Perform Topology Check (optional)

Simplify Line Tolerance  
0.00328084 Feet

**Bearing Change Threshold (degrees)**  
1

Maximum Distance  
1040.03 Feet

Output Observed Curve Lines  
\\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\01

Output Perfect Fitted Curves  
\\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\01

Angle Resolution for Output Perfect Fitted Curves  
0.5

**Bearing Change Threshold (degrees)**

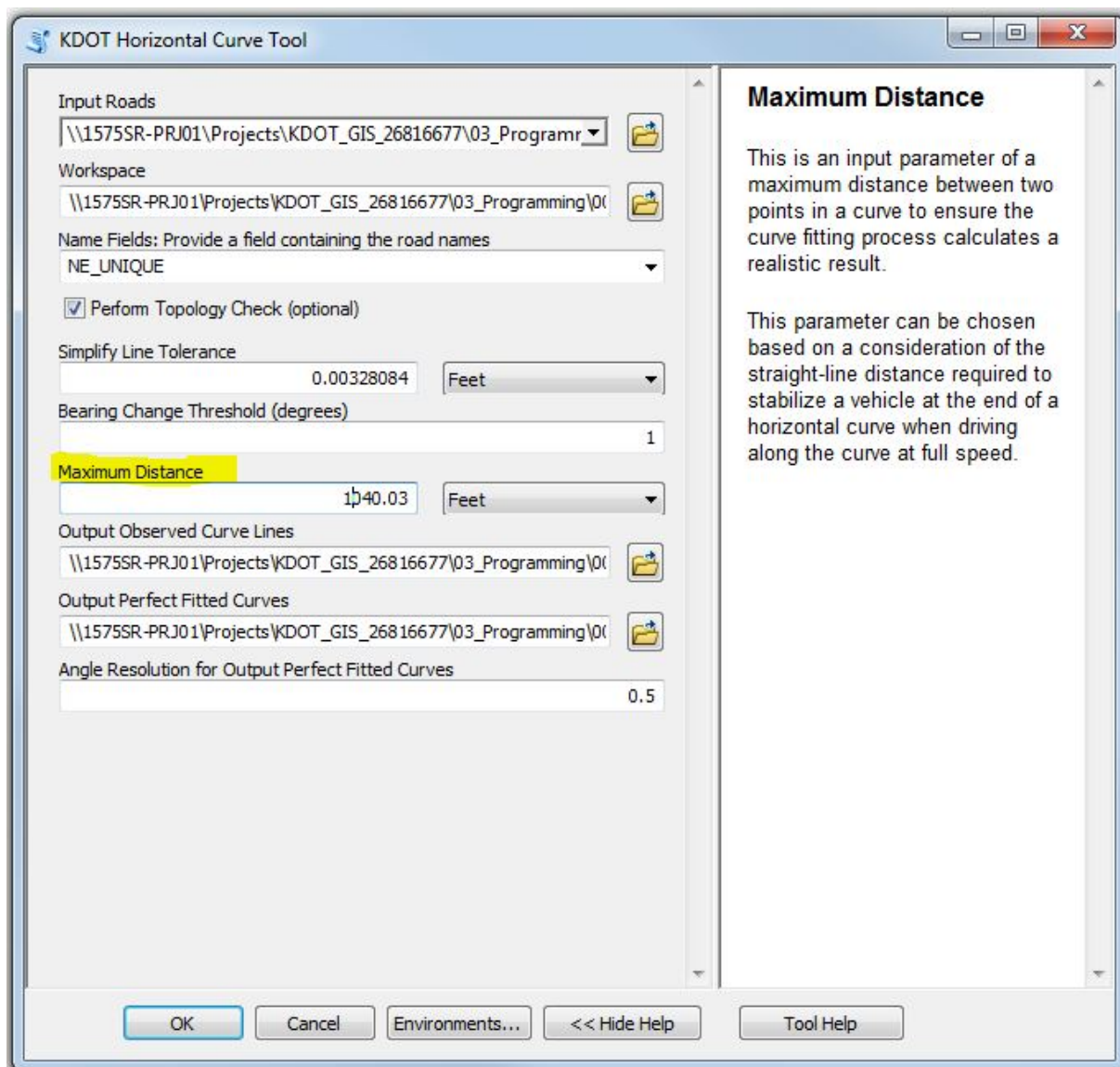
This is the angle change threshold between consecutive road line segments used in the curve-detection process.

If the angle between two sequential line segments is greater than or equal to this threshold, a curve start is indicated. If the angle is less than this threshold, OR if the direction of the road changes, i.e., clockwise to counter-clockwise or vice versa, the curve stops.

OK Cancel Environments... << Hide Help Tool Help

This is the threshold in degrees used in the curve detection algorithm. A curve beginning is defined where the change in degrees between any two road segments exceeds this threshold, and an end is defined where it falls below this threshold OR if the direction (clockwise or counter-clockwise) reverses.

### 3.7 Maximum Distance



The screenshot shows the 'KDOT Horizontal Curve Tool' dialog box. The 'Maximum Distance' parameter is highlighted in yellow. The value is 1040.03 feet. The right pane provides a detailed explanation of this parameter.

**Maximum Distance**

This is an input parameter of a maximum distance between two points in a curve to ensure the curve fitting process calculates a realistic result.

This parameter can be chosen based on a consideration of the straight-line distance required to stabilize a vehicle at the end of a horizontal curve when driving along the curve at full speed.

Input Roads: \\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programr

Workspace: \\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\00

Name Fields: Provide a field containing the road names  
NE\_UNIQUE

☒ Perform Topology Check (optional)

Simplify Line Tolerance: 0.00328084 Feet

Bearing Change Threshold (degrees): 1

Maximum Distance: 1040.03 Feet

Output Observed Curve Lines: \\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\00

Output Perfect Fitted Curves: \\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\00

Angle Resolution for Output Perfect Fitted Curves: 0.5

Buttons: OK, Cancel, Environments..., << Hide Help, Tool Help

This is an input parameter of a maximum distance between two points in a curve to ensure the curve fitting process calculates a realistic result. This parameter can be chosen based on a consideration of the straight-line distance required to stabilize a vehicle at the end of a horizontal curve, when driving along the curve at full speed. The default is 1040.03 feet, or 317 meters.

Please note that the default value will only affect curves with a very large radius. Increase this value to enable detection of very broad curves.

### 3.8 Output Observed Curve Lines (Feature Class)

**KDOT Horizontal Curve Tool**

Input Roads  
 \\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programr

Workspace  
 \\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\0

Name Fields: Provide a field containing the road names  
 NE\_UNIQUE

☒ Perform Topology Check (optional)

Simplify Line Tolerance  
 0.00328084 Feet

Bearing Change Threshold (degrees)  
 1

Maximum Distance  
 1040.03 Feet

**Output Observed Curve Lines**  
 \\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\0

Output Perfect Fitted Curves  
 \\1575SR-PRJ01\Projects\KDOT\_GIS\_26816677\03\_Programming\0

Angle Resolution for Output Perfect Fitted Curves  
 0.5

**Output Observed Curve Lines**

This is an output feature POLYLINE class containing the observed curves of the input roads.

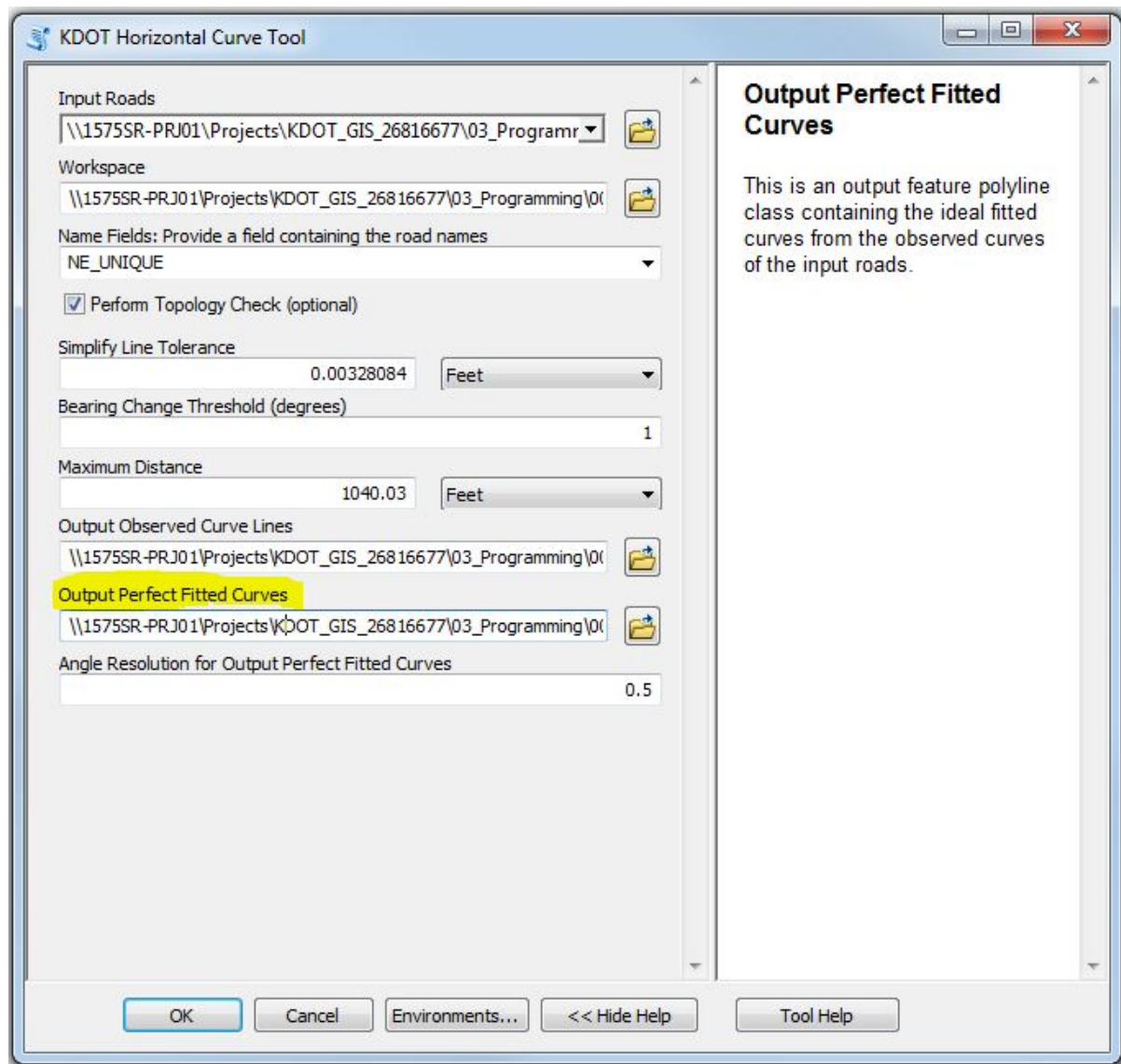
OK Cancel Environments... << Hide Help Tool Help

This is an output feature POLYLINE class containing the observed curves of the input roads. The output attribute table contains the original FID of the road, the unique ID as from the selected field, and the CurveID which is a unique identifier using the original FID and the vertex positions. For example:

OBJECTID *	Shape *	Shape_Length	Original_OID	Unique_ID	CurveID
32	Polyline	2276.936085	1	029U0005000-EB	4_10_1



### 3.9 Output Best-Fit Curves (Feature Class)

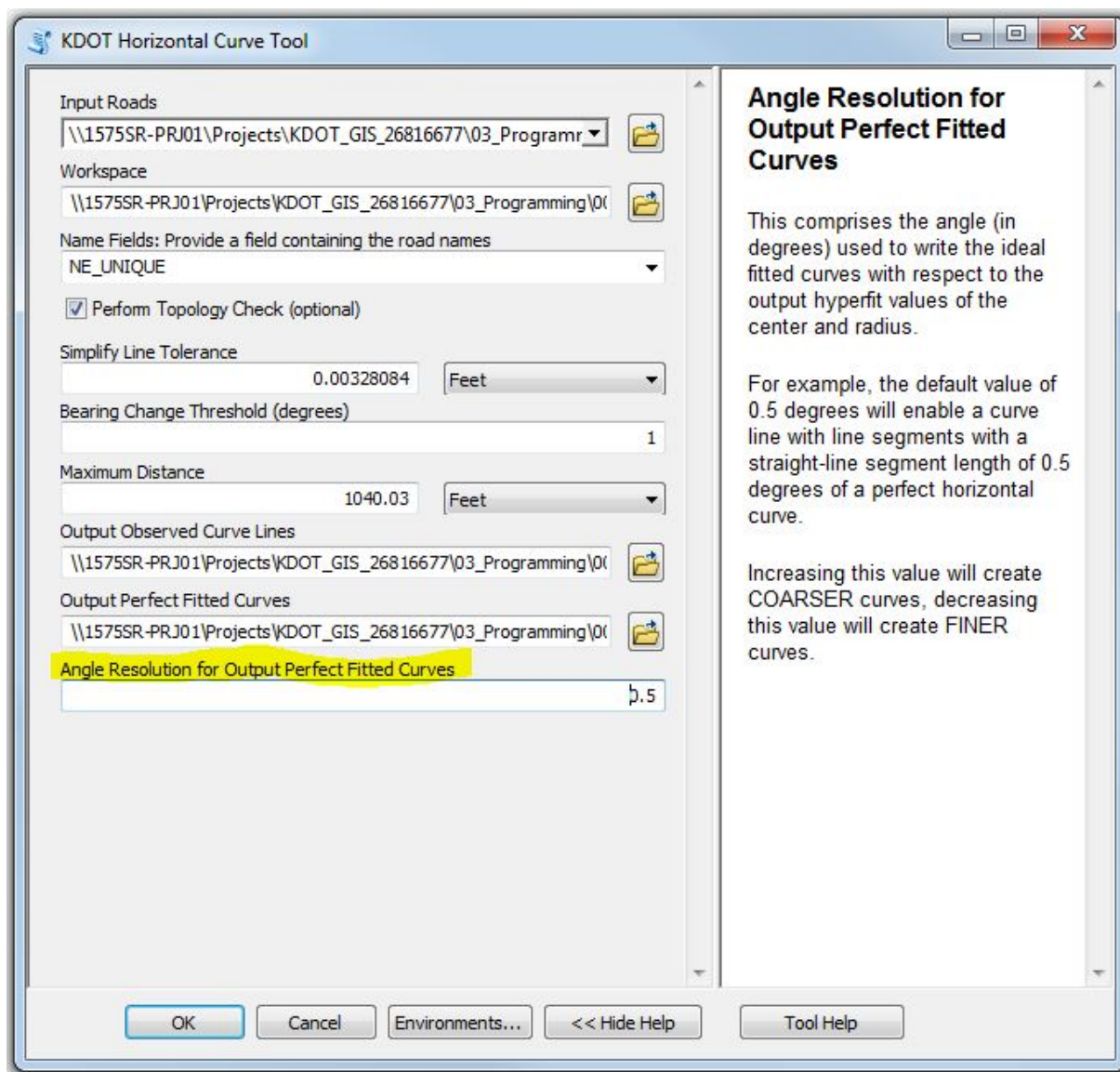


This is an output feature POLYLINE class containing the best-fit curves from the observed curves of the input roads. This attribute table contains the same values as in the observed curve feature class, plus two values for the R-squared statistic, the center of the best-fit curve, the radius of the best-fit curve, and start and end coordinates of the observed curve. For example:

R_Squared	R_Squared_Dense	X_Center	Y_Center	Radius	X_Start	Y_Start	X_End	Y_End
1	1	743784.040 4	647598.179 6	11300.6095 7	745785.177 6	658720.698 8	747970.447 1	658094.413

“R\_Squared” is calculated using only the points of the observed curve, whereas “R\_Squared\_Dense” is calculated using the vertices along the observed curve at the same radial location as the best-fit curve vertices with respect to the curve center. The values of “R\_Squared\_Dense” will never exceed “R\_Squared.”

### 3.10 Angle Resolution for Best-Fit Curves



This comprises the angle (in degrees) used to write the best-fit curves with respect to the output Hyperfit values of the center and radius. For example, the default value of 0.5 degrees will enable a curve line with line segments with a straight-line segment length of 0.5 degrees of a perfect horizontal curve. Increasing this value will create **coarser** curves, decreasing this value will create **finer** curves.

## FIGURES

---

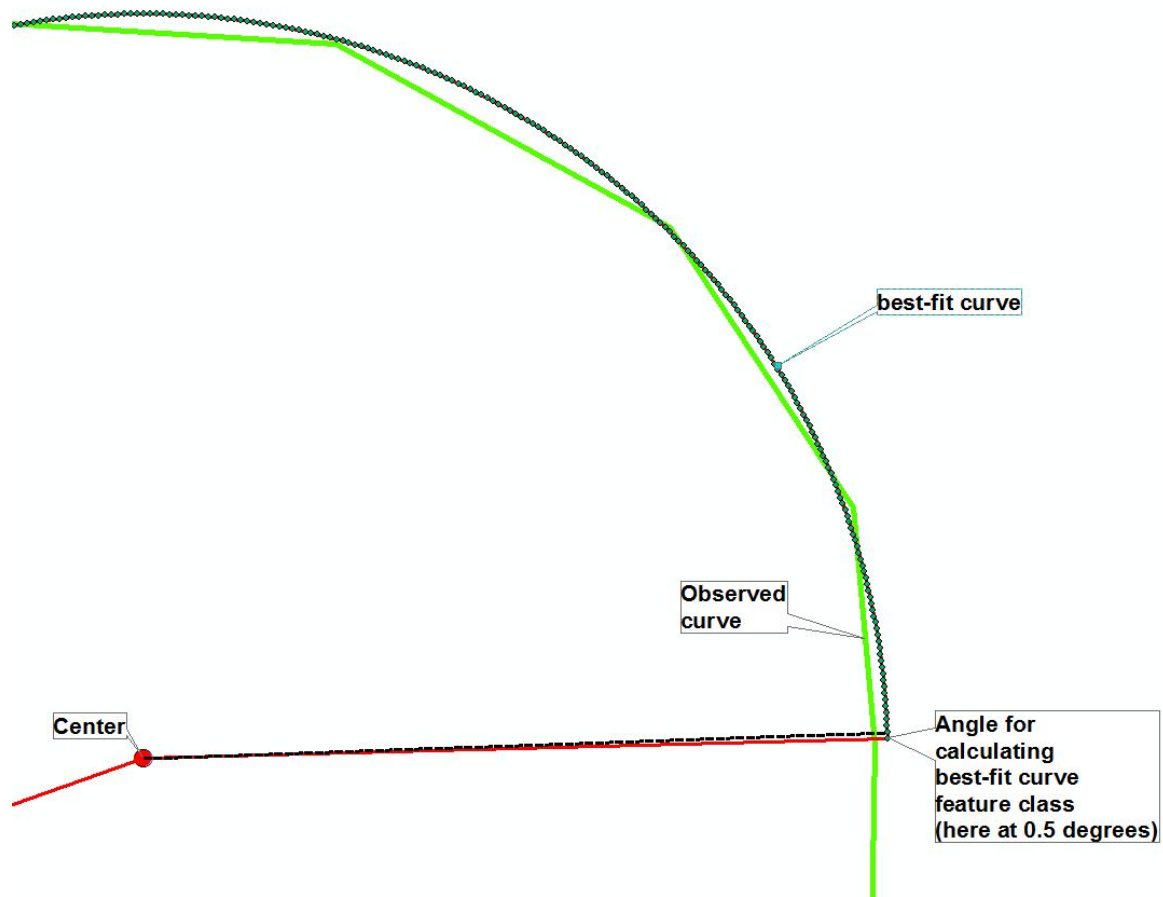


Figure 1. Observed versus best-fit curve and angle resolution for resulting feature class