Selected Math Topics in the Network Geometry GDS

May 2007

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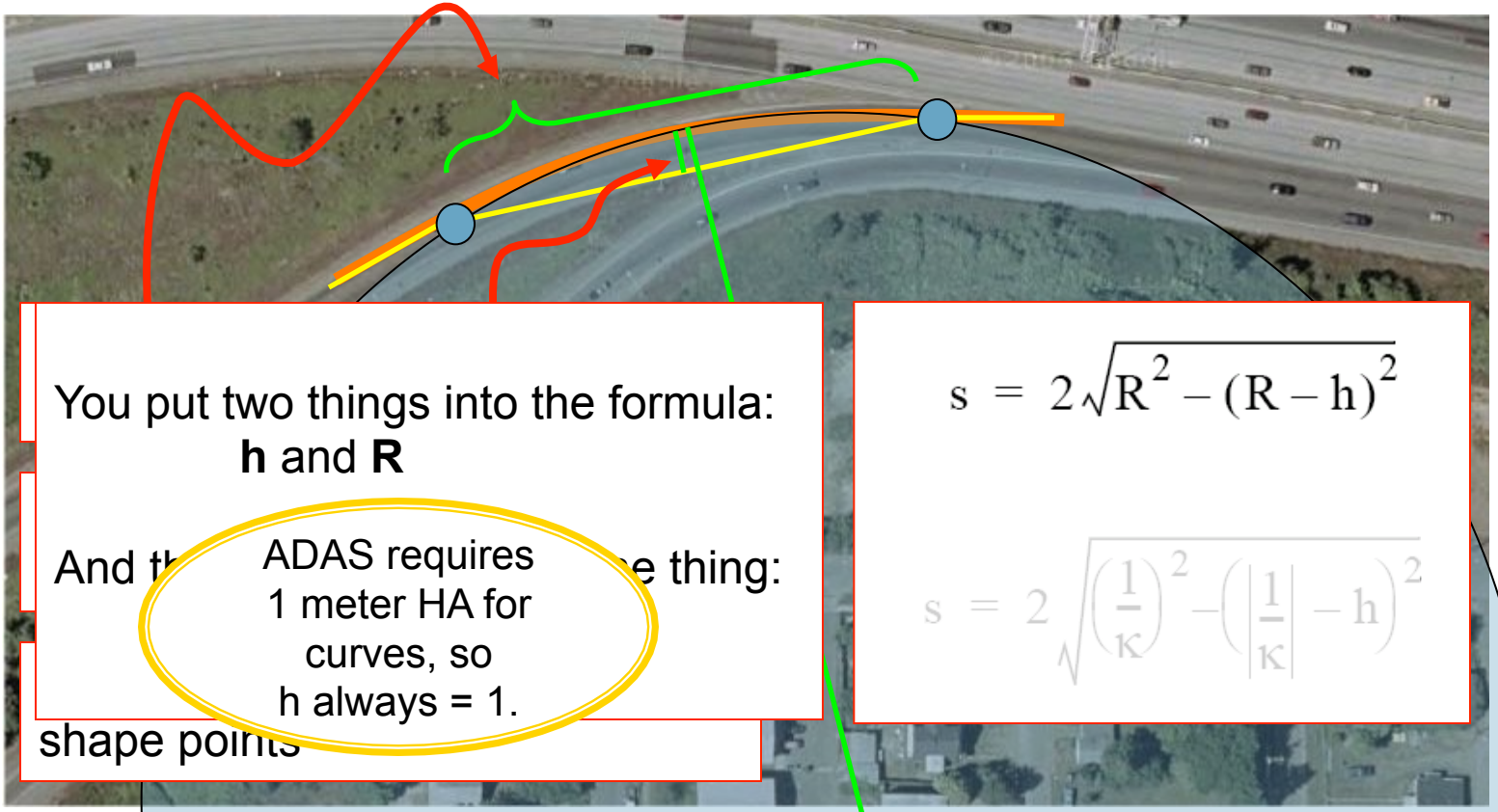
Topics

- Shape Point Density Formula
  Section 5.1: Shape point density
- Definition of a Clothoid
  Section 5.2: Smooth transition
- Definition of a Tangent
  Section 5.3: Forks with legal separation
- The Sign of a Curve
  Figure 79: Forks with legal separation

Section 5.1: Shape point density

- The specification contains a pair of formulas that describe how far apart you can place shape points in a curve and still meet a horizontal accuracy (HA) requirement.
- Since ADAS requires 1 meter HA, we can use the formulas to calculate the maximum distance between shape points while still being ADAS compliant.
- **It is not practical to use this formula for manual editing.** It is used for tool development and quality control.

Section 5.1: Shape point density



You put two things into the formula:
h and **R**

And th e thing:

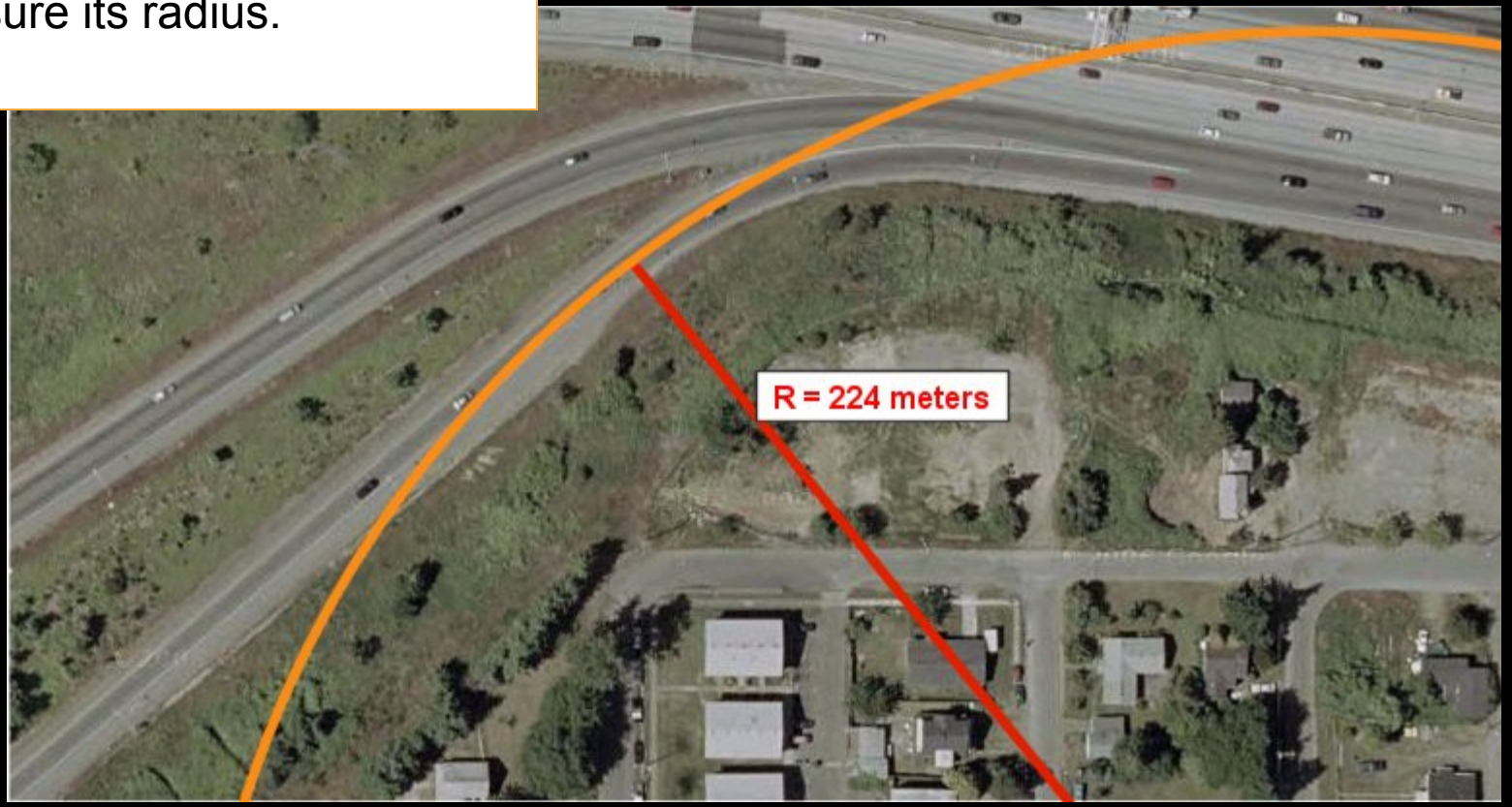
ADAS requires 1 meter HA for curves, so h always = 1.

shape points

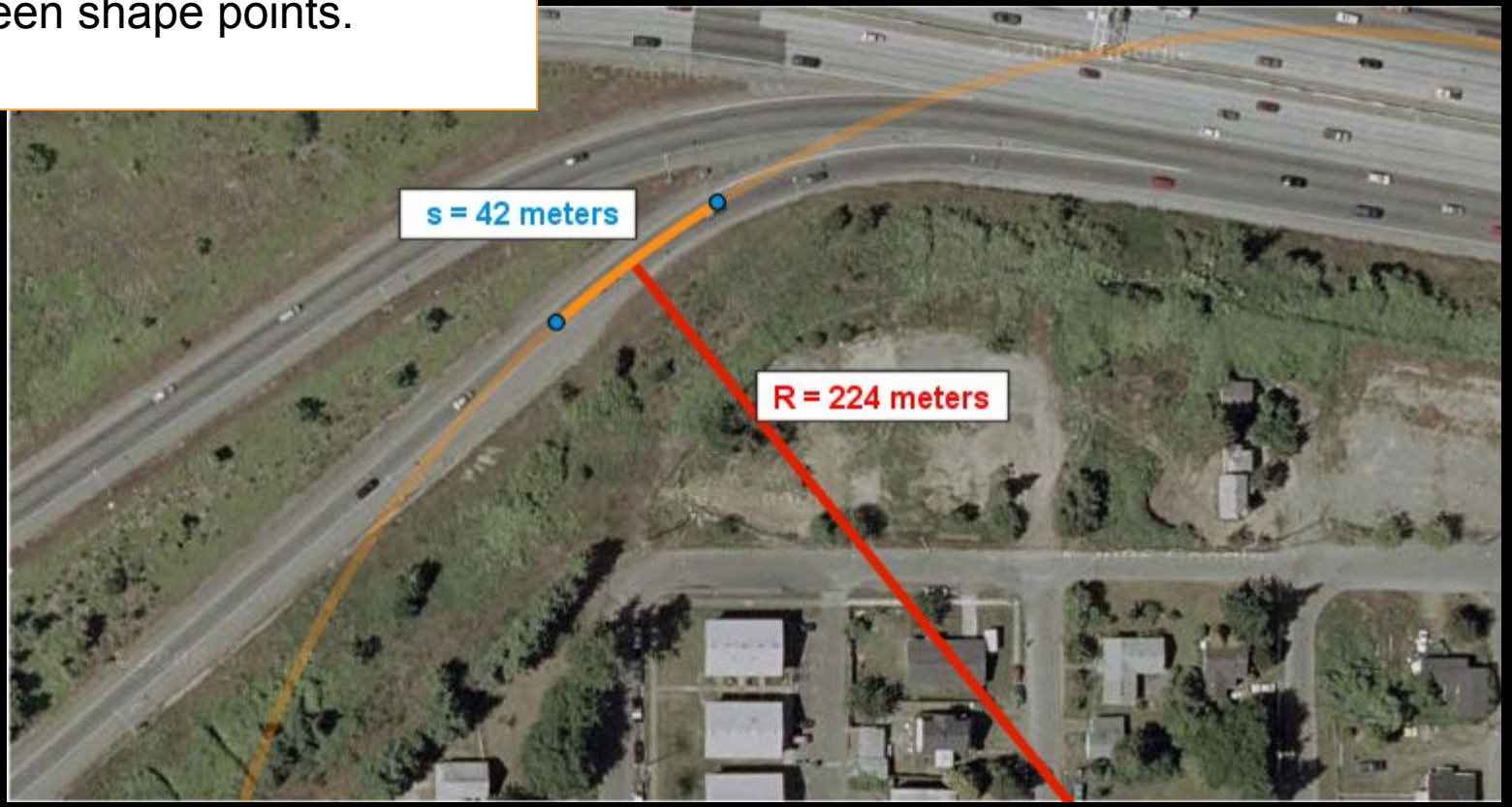
$$s = 2\sqrt{R^2 - (R - h)^2}$$

$$s = 2\sqrt{\left(\frac{1}{\kappa}\right)^2 - \left(\left|\frac{1}{\kappa}\right| - h\right)^2}$$

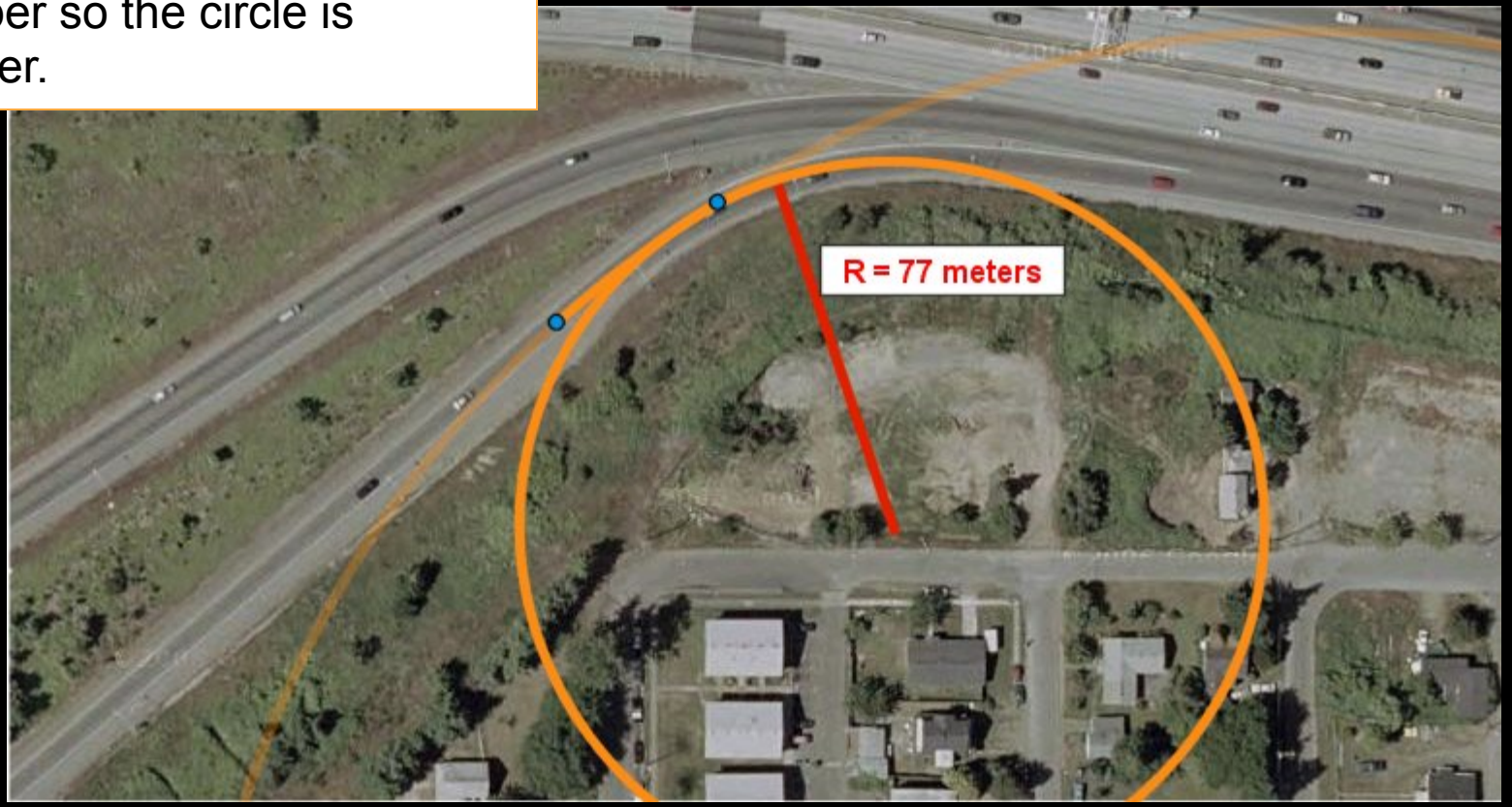
Draw a circle that best fits the first part of the curve. Then measure its radius.



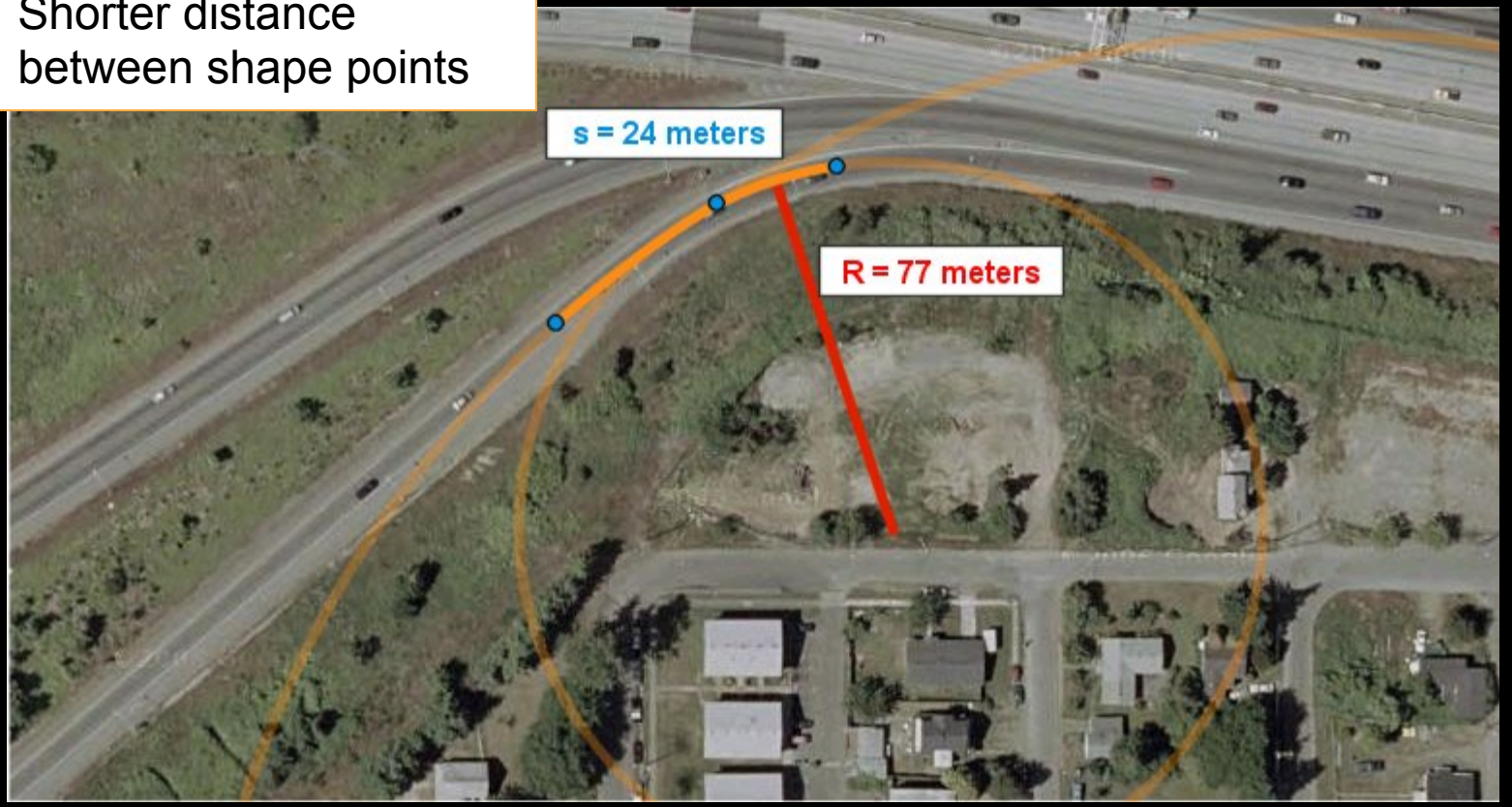
Use the formula to figure out the maximum distance between shape points.



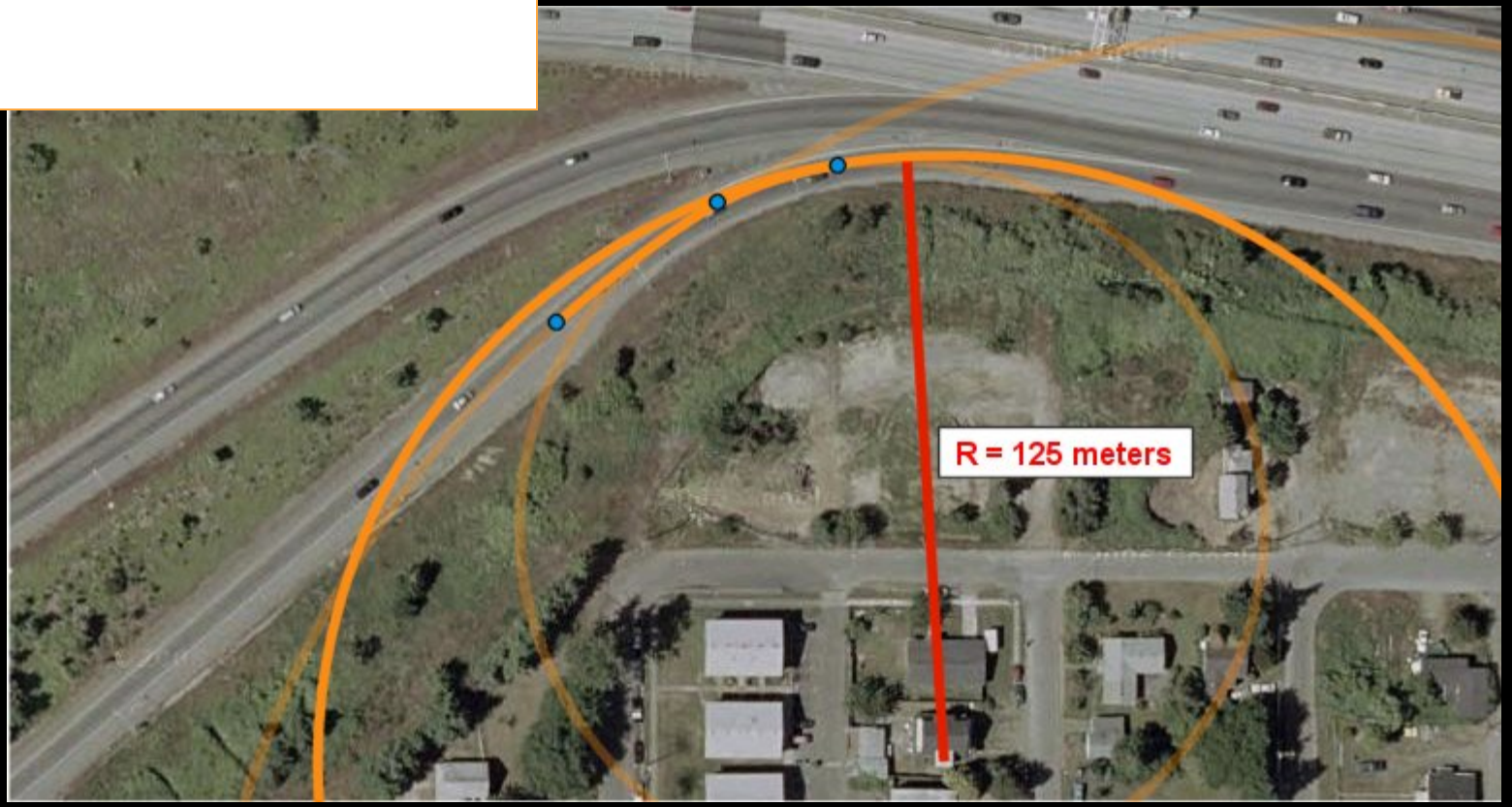
Draw a new circle for the next part of the curve. The curve is sharper so the circle is smaller.



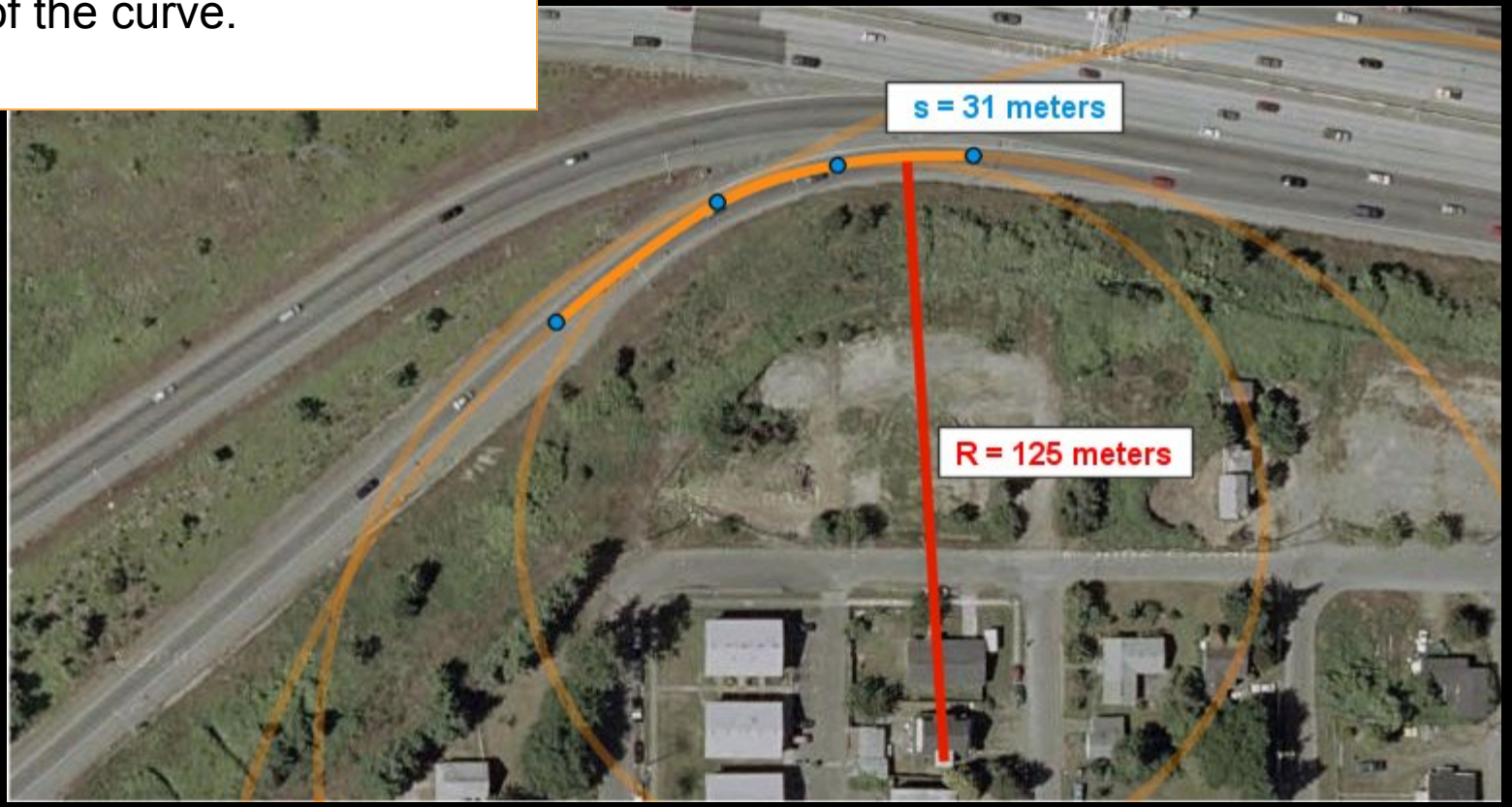
Tighter curves =
    Smaller circles =
        Shorter distance
        between shape points



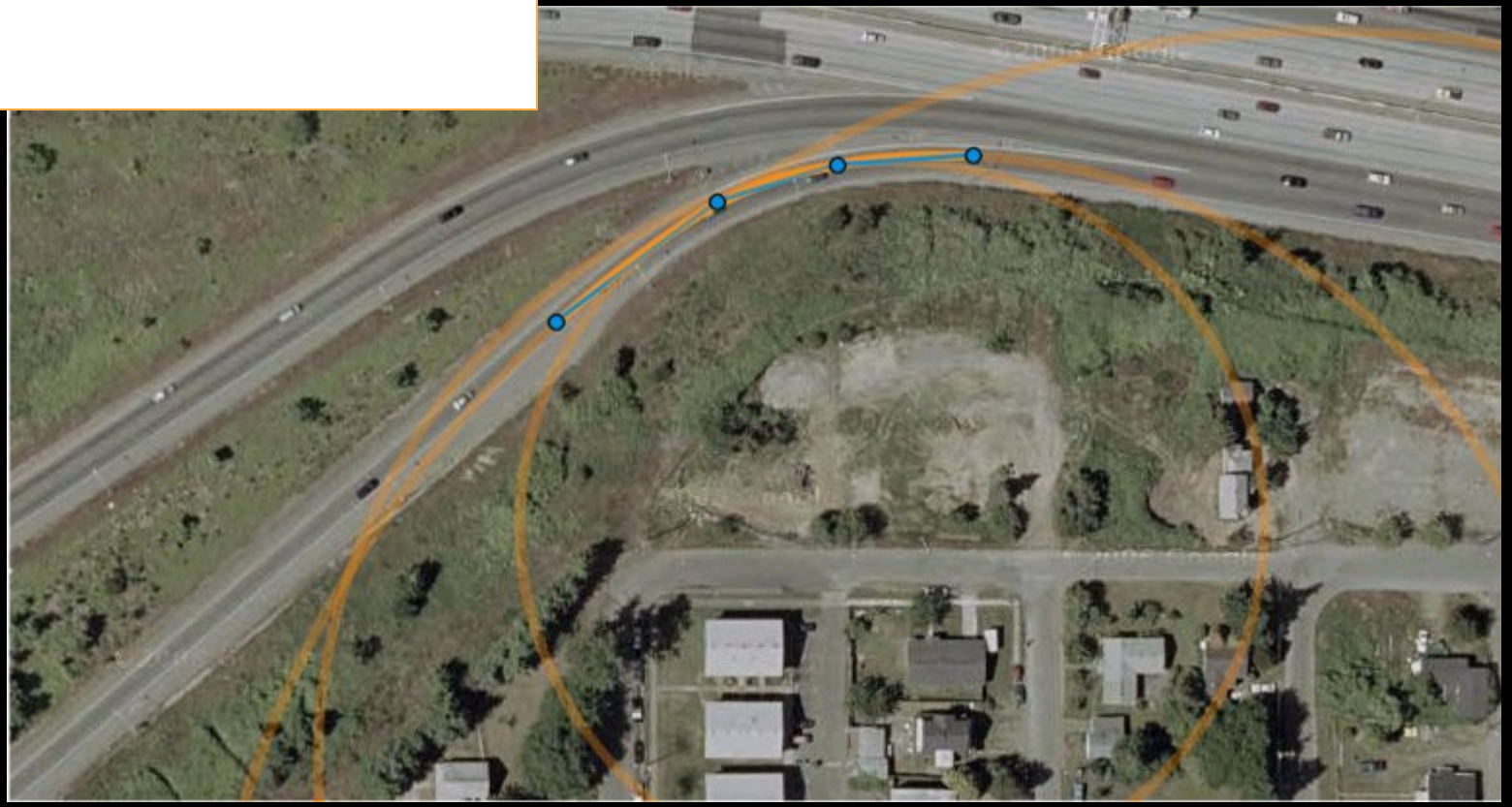
Repeat the process again for the third part of the curve.



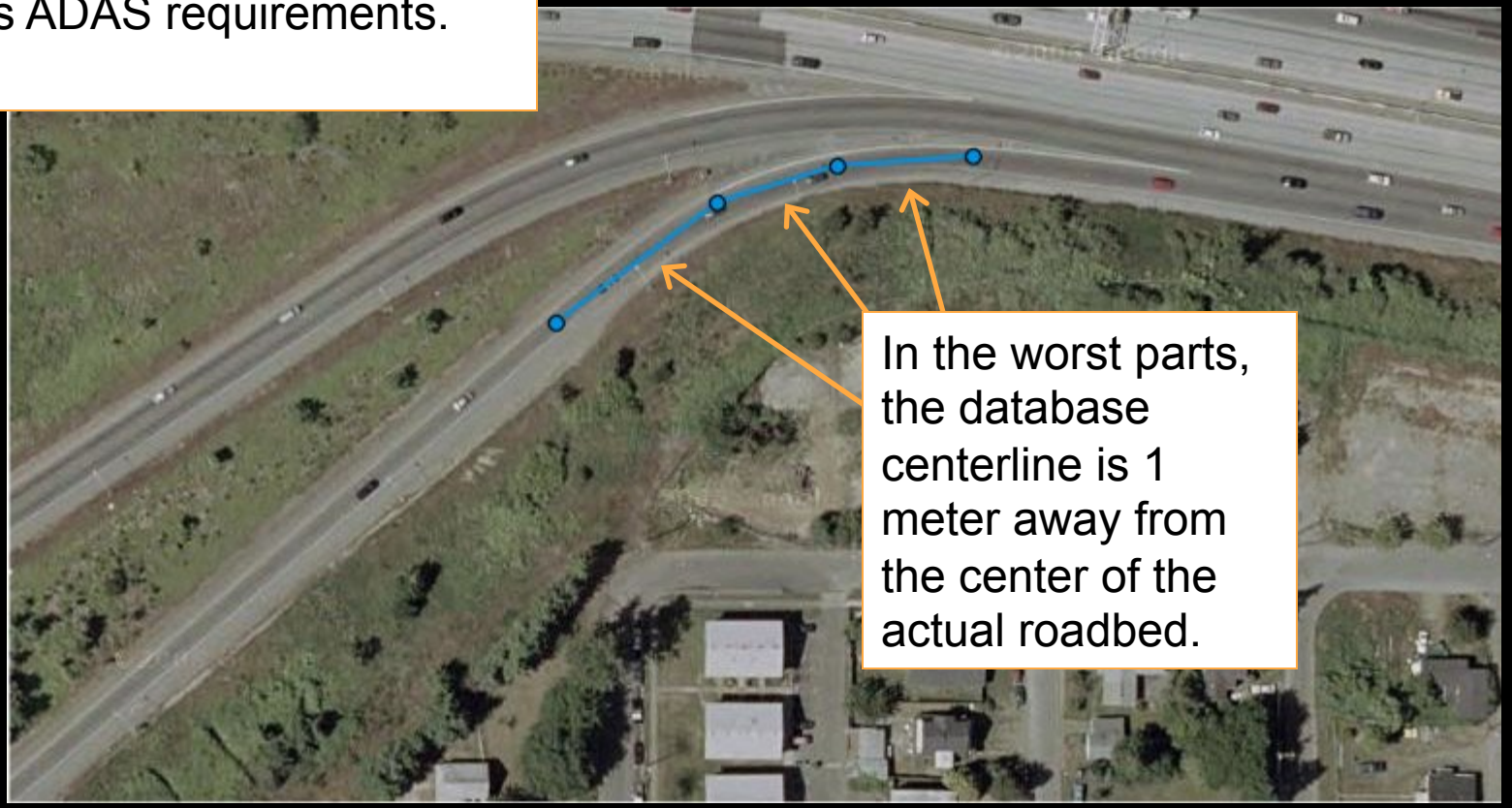
Notice that the distance required is different for each part of the curve.



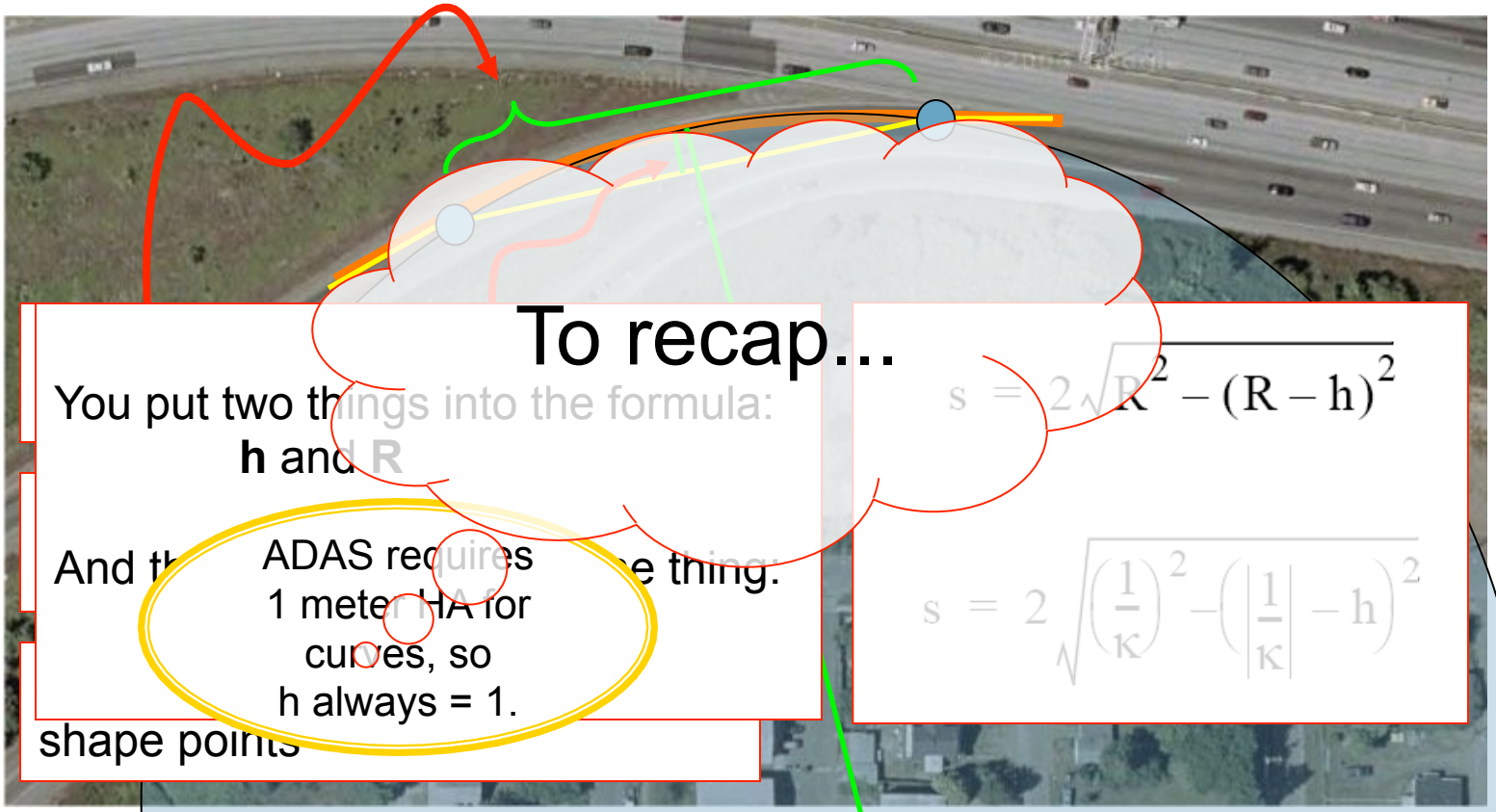
When we connect our shape points now ...

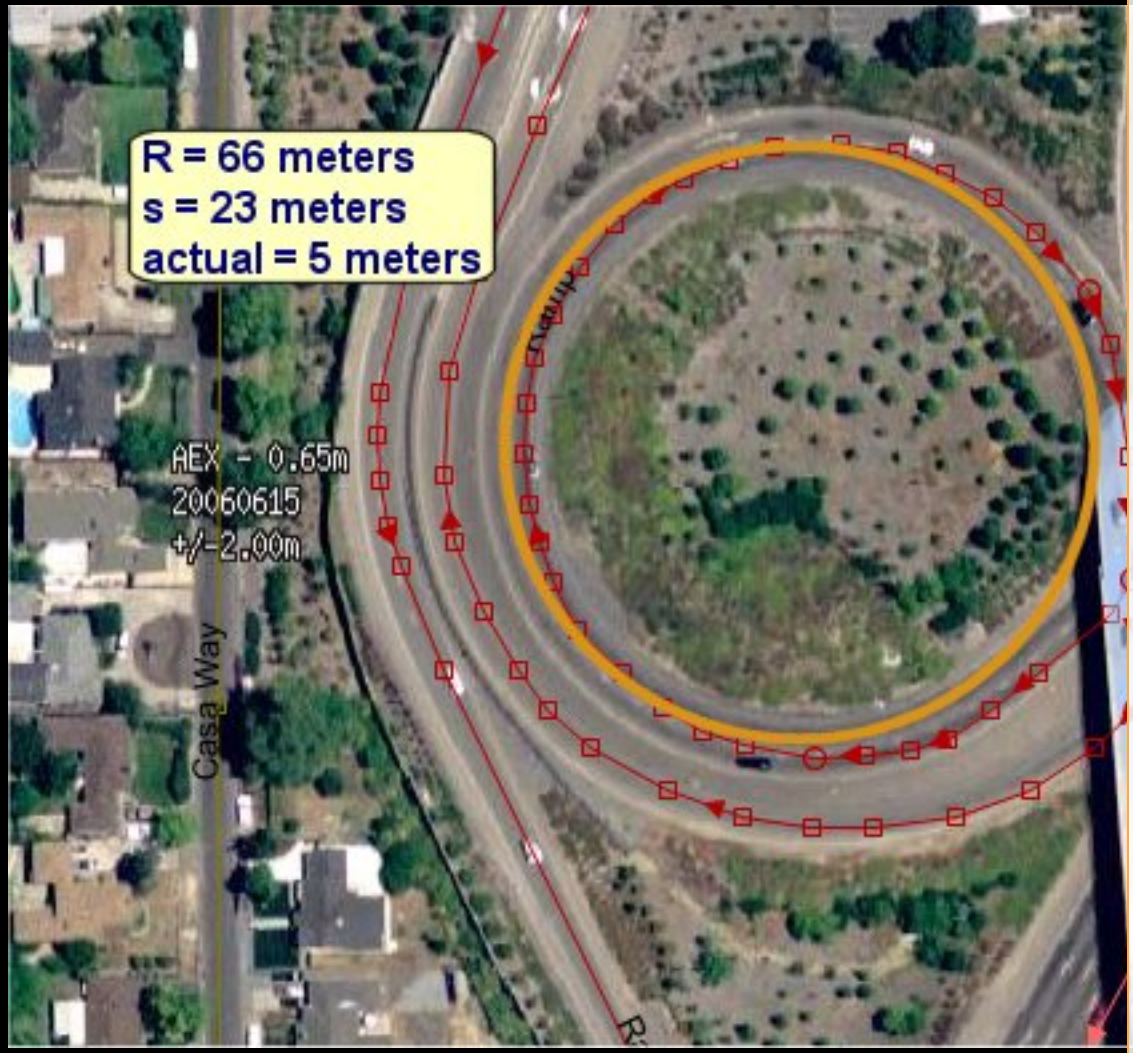


The formula gives us a centerline that *just barely* meets ADAS requirements.



Section 5.1: Shape point density





Note the **orange line**. That is part of the circle that best fits the sharpest part of the curve. Its radius is

66 meters,

which means the maximum distance between shape points is

23 meters.

In the situation shown, the actual maximum distance between shape points is

5 meters.

This means the curve **does** meet the ADAS requirements for shape point density.

Note the **orange line**. That is part of the circle that best fits the sharpest part of the curve. Its radius is

160 meters,

which means the maximum distance between shape points is

35 meters.

In the situation shown, the actual maximum distance between shape points is

26 meters.

This means the curve **does** meet the ADAS requirements for shape point density.

Note the **orange line**. That is part of the circle that best fits the sharpest part of the curve. Its radius is

590 meters,

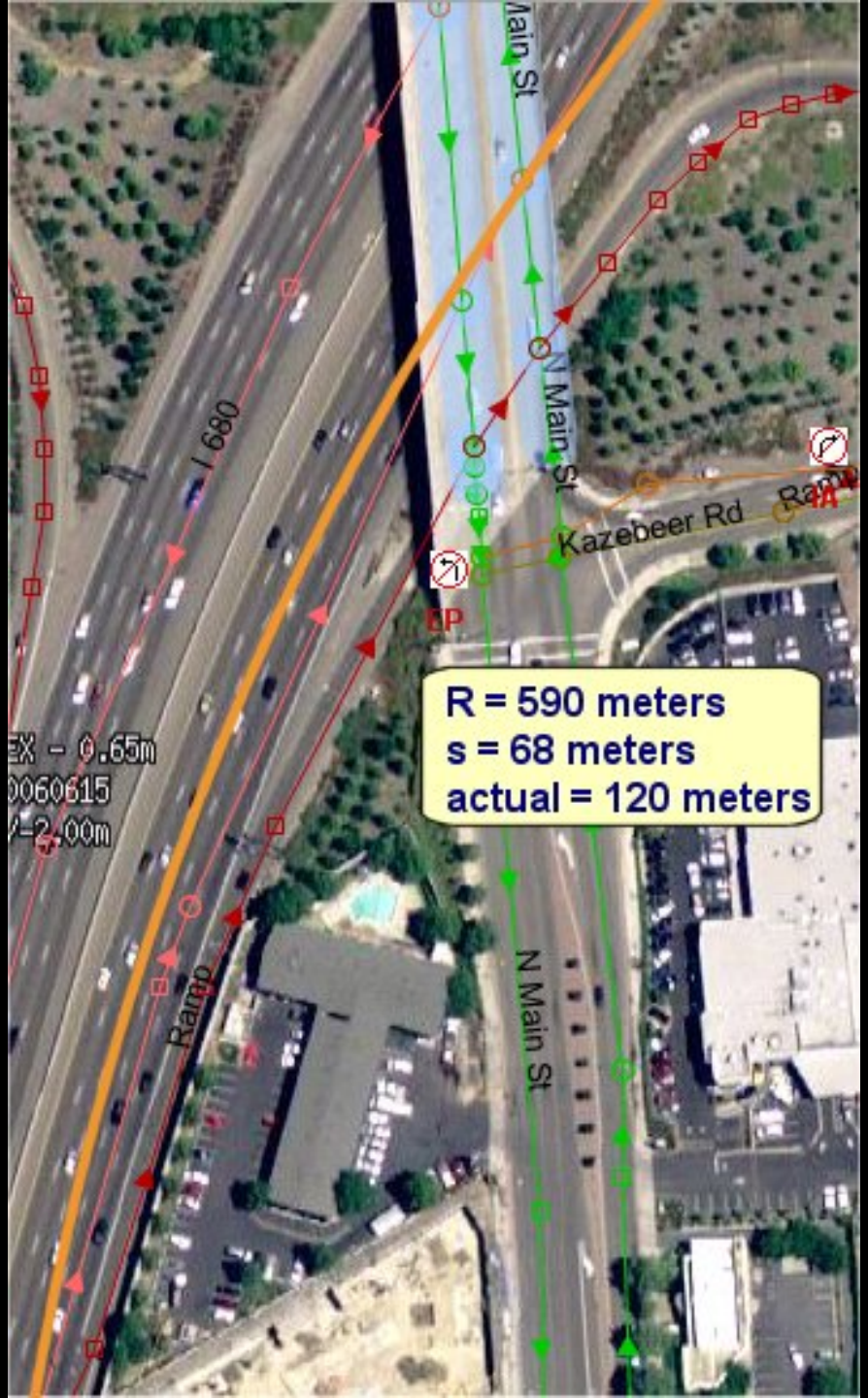
which means the maximum distance between shape points is

68 meters.

In the situation shown, the actual maximum distance between shape points is

120 meters.

This means the curve **does not** meet the ADAS requirements for shape point density.



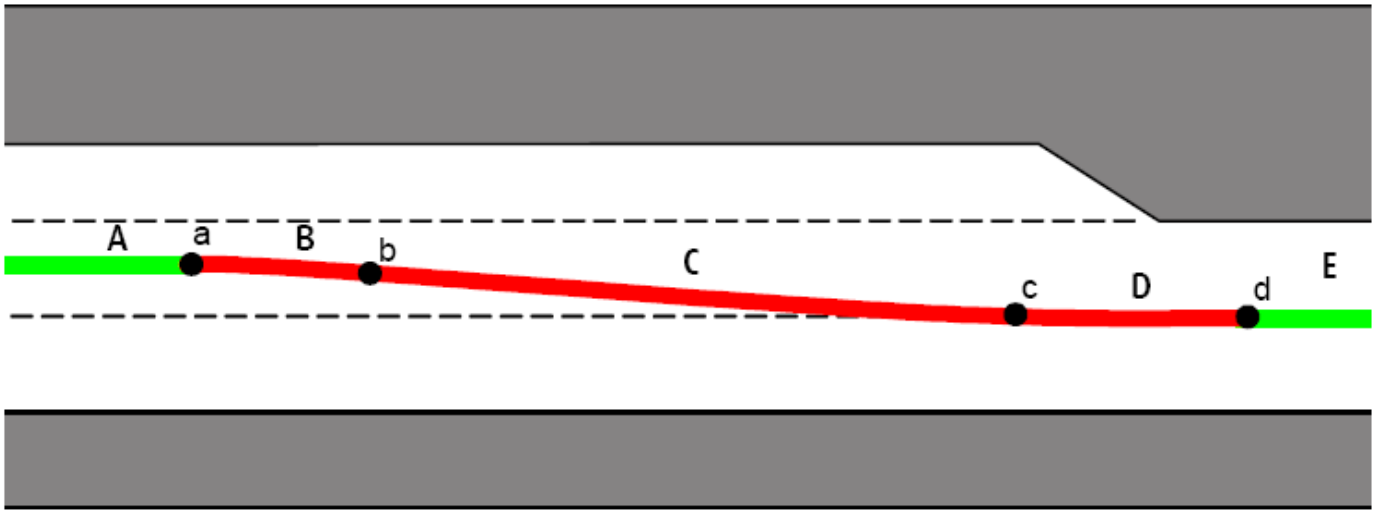
Topics

- ✓ Shape Point Density Formula
  Section 5.1: Shape point density
- Definition of a Clothoid
  Section 5.2: Smooth transition
- Definition of a Tangent
  Section 5.3: Forks with legal separation
- The Sign of a Curve
  Figure 79: Forks with legal separation

Section 5.2: Smooth transition

The specification requires that transition segments be shaped like clothoids.

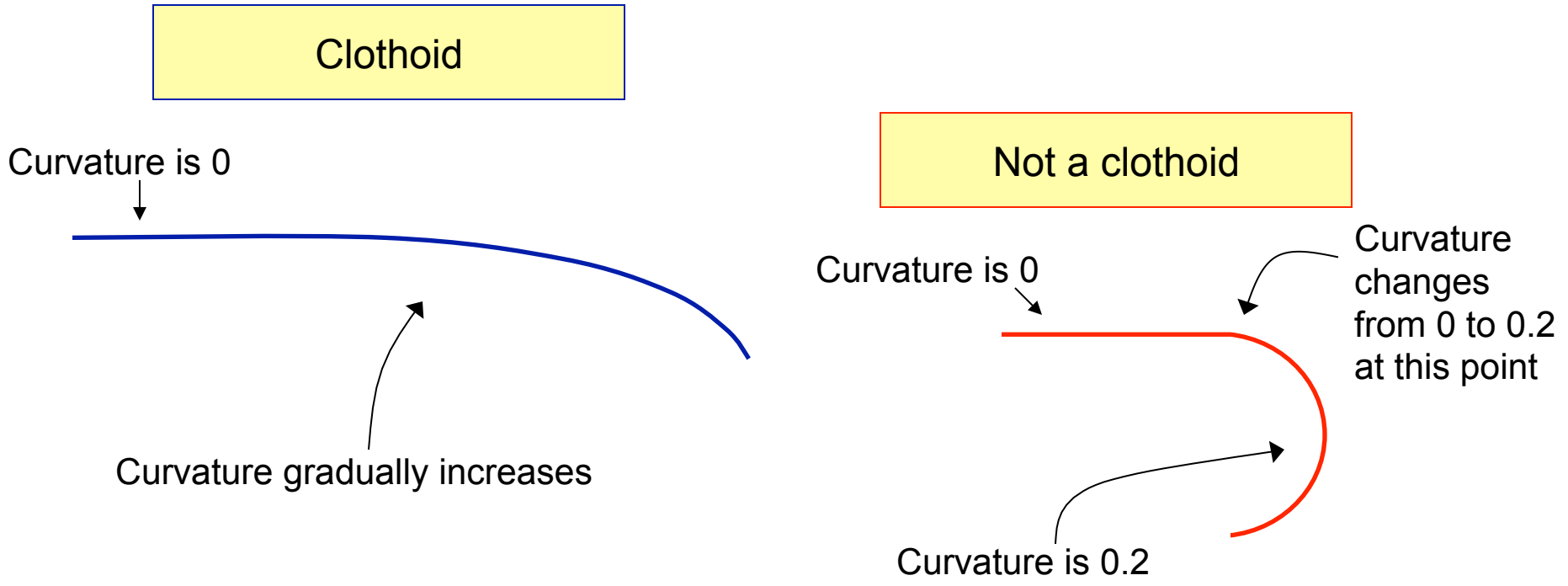
What does that mean?



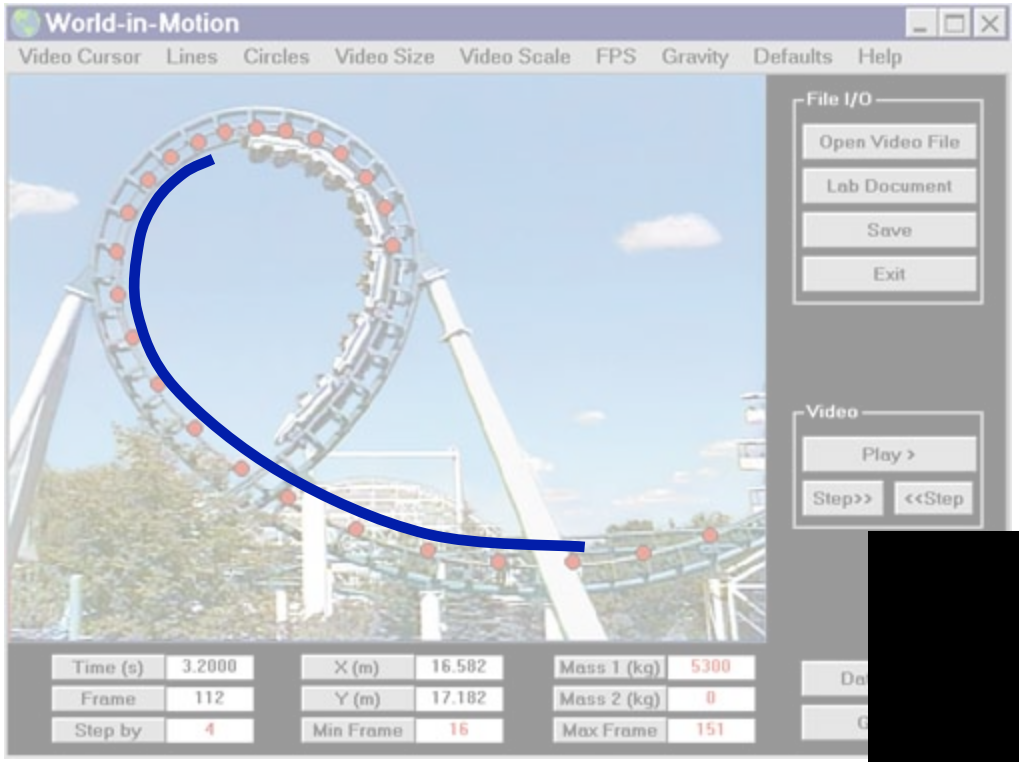
Section 5.2: Smooth transition

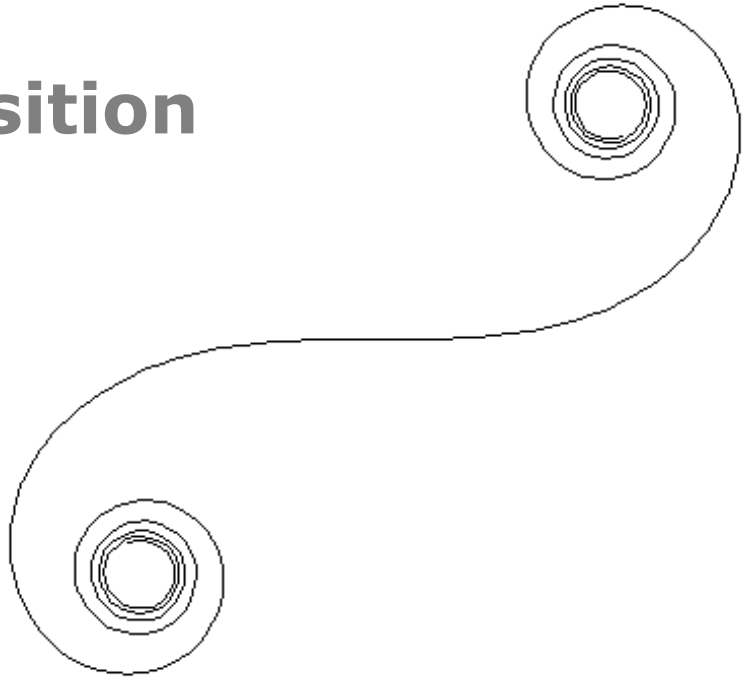
Clothoid *(n).*

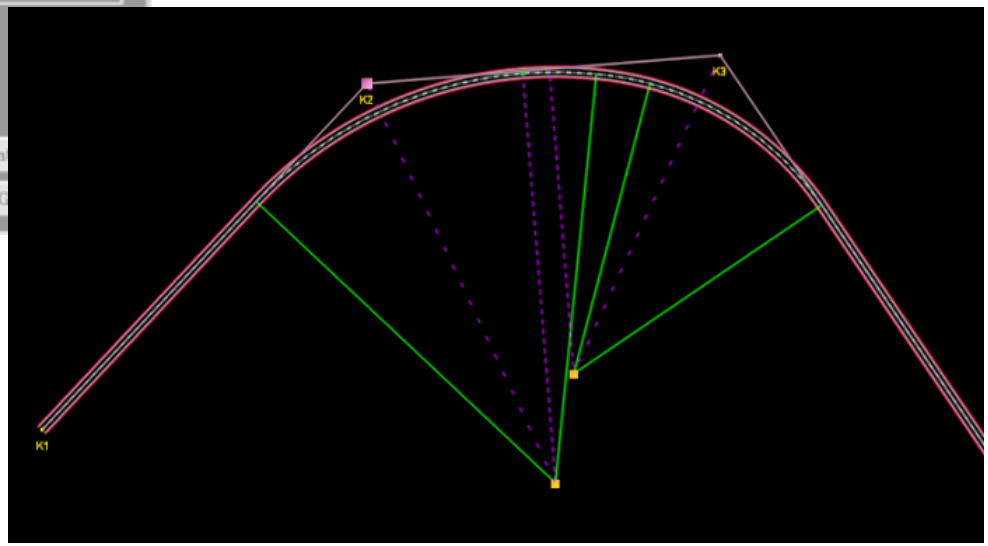
a line whose curvature changes at a constant rate; it provides a gentle transition between a straight line and a curve



Section 5.2: Smooth transition







These sample clothoids all provide gentle transition between straight lines and curves.

Tele Atlas Find more.

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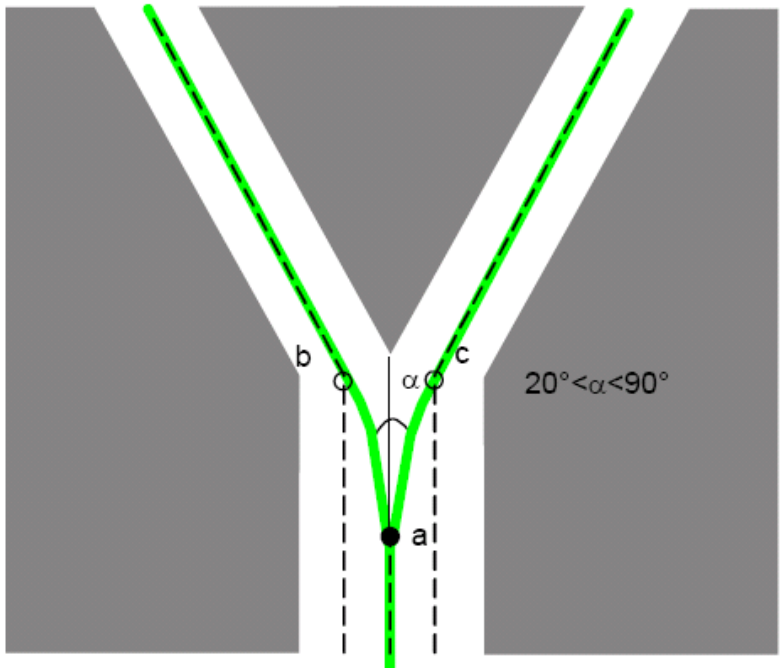
Section 5.3: Forks with legal separation

The specification requires that "the tangent of the curve correspond with the tangent of the centerline."

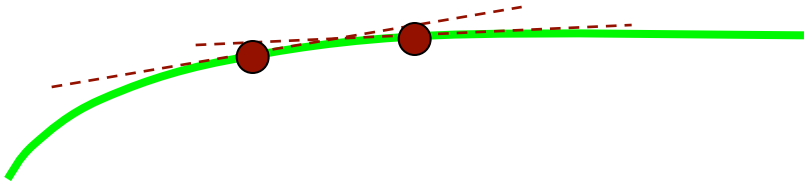
What does this mean?



Section 5.3: Forks with legal separation

Tangent *(n).*

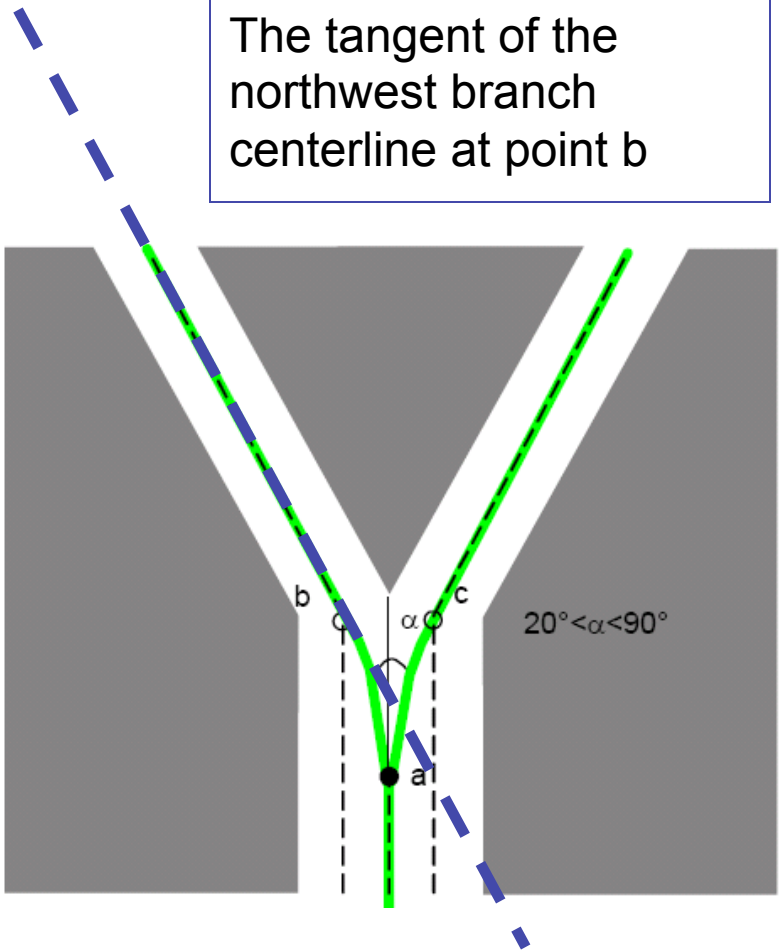
a line that touches a curve only once



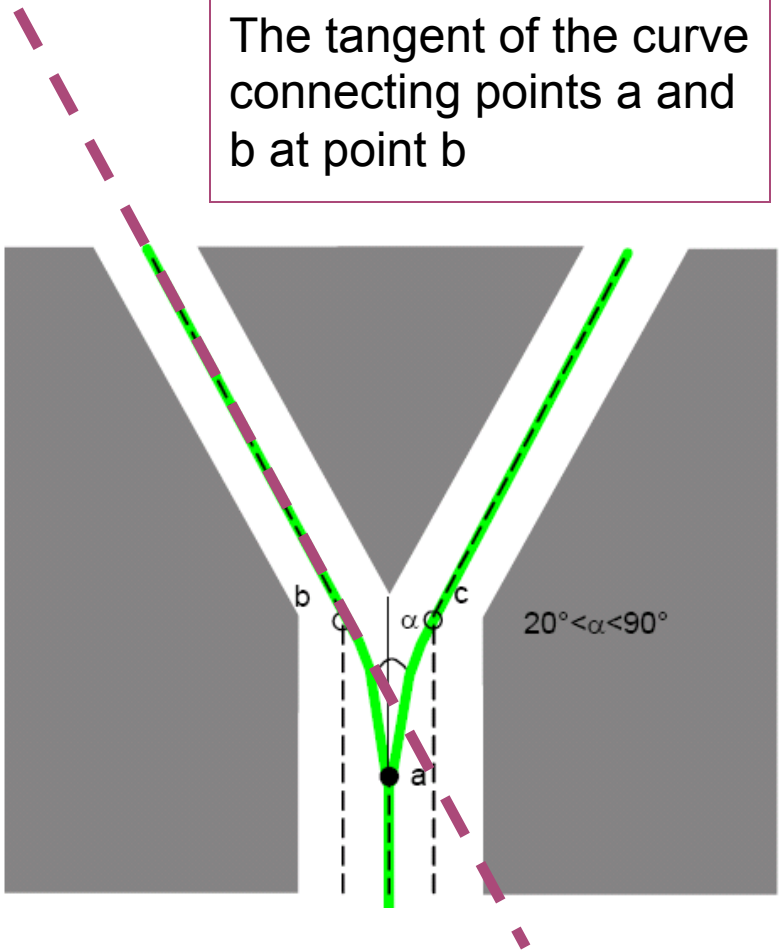
Or in the case of a straight line, the line itself could be considered the tangent.

Section 5.3: Forks with legal separation

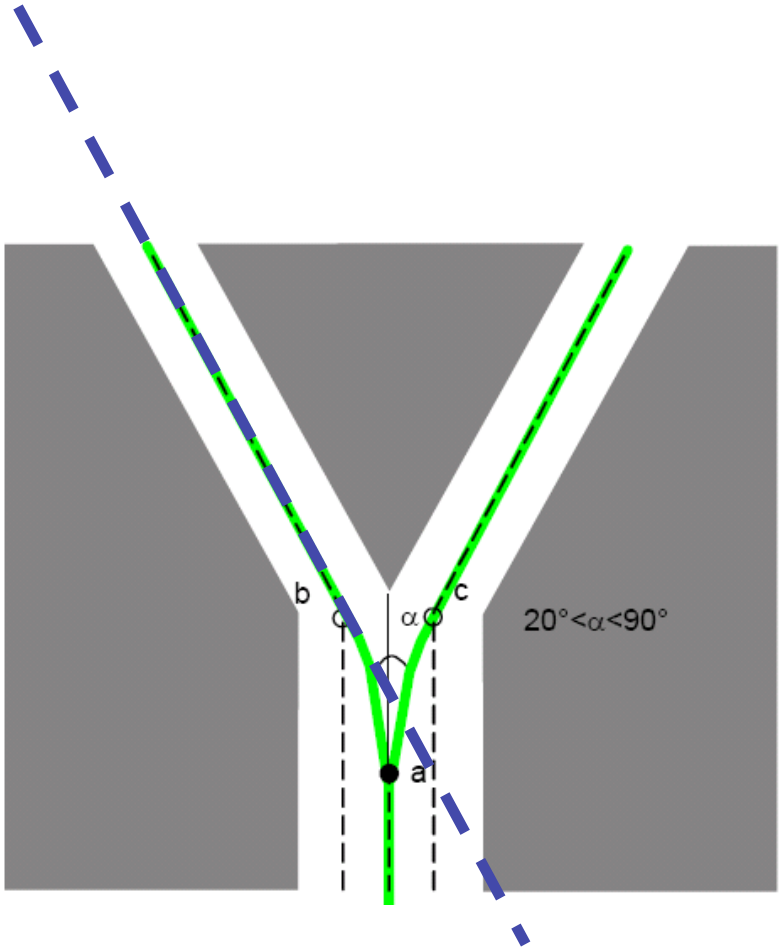
The tangent of the northwest branch centerline at point b



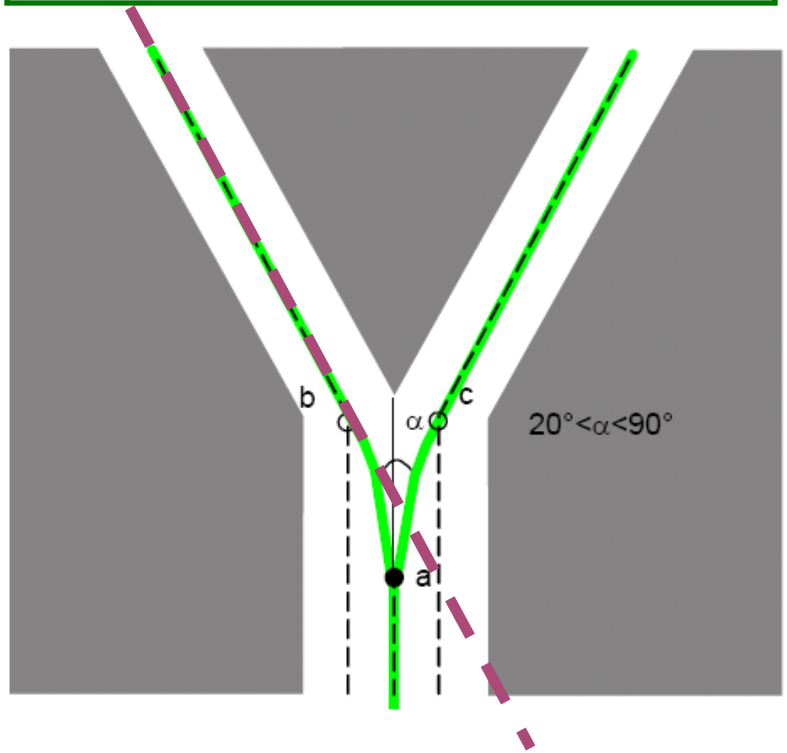
The tangent of the curve connecting points a and b at point b



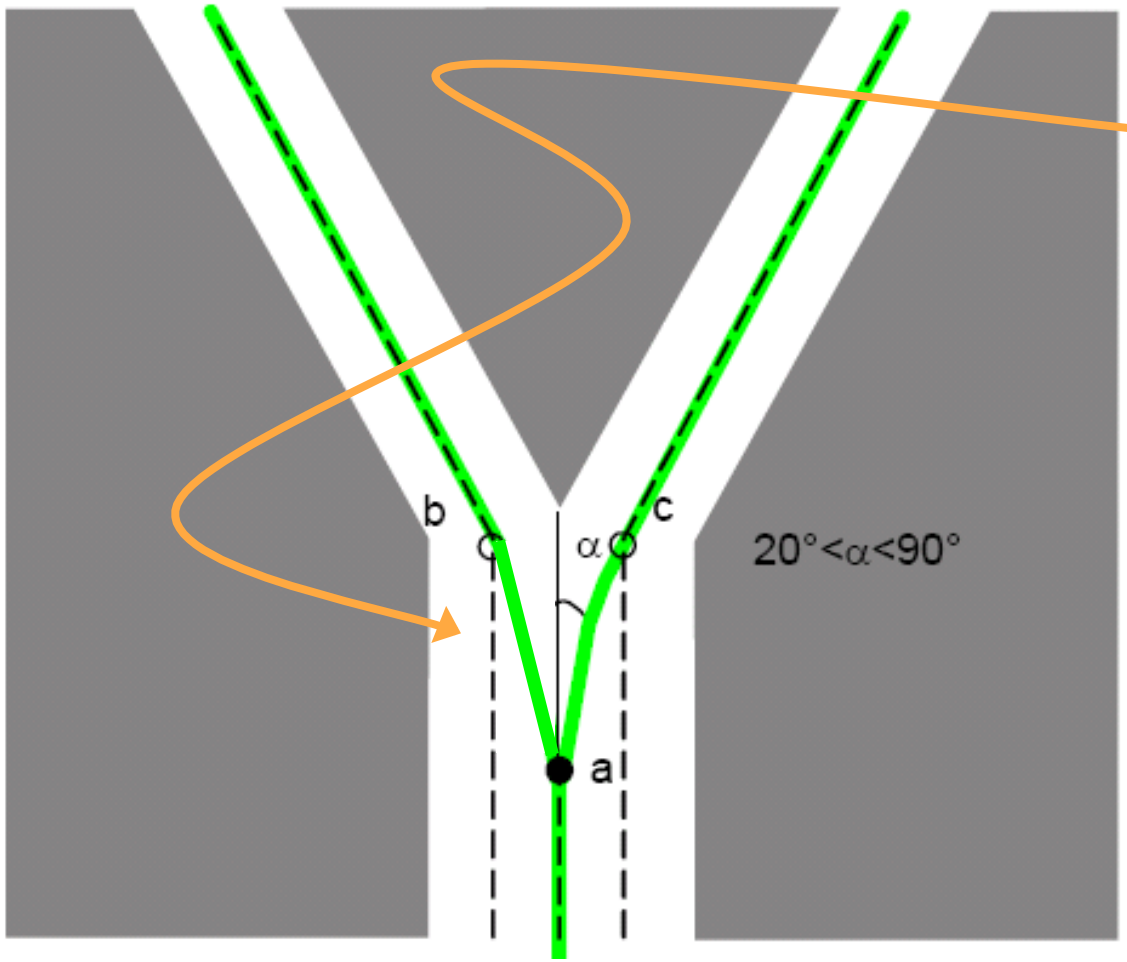
Section 5.3: Forks with legal separation



In this scenario, these two tangents are the same.

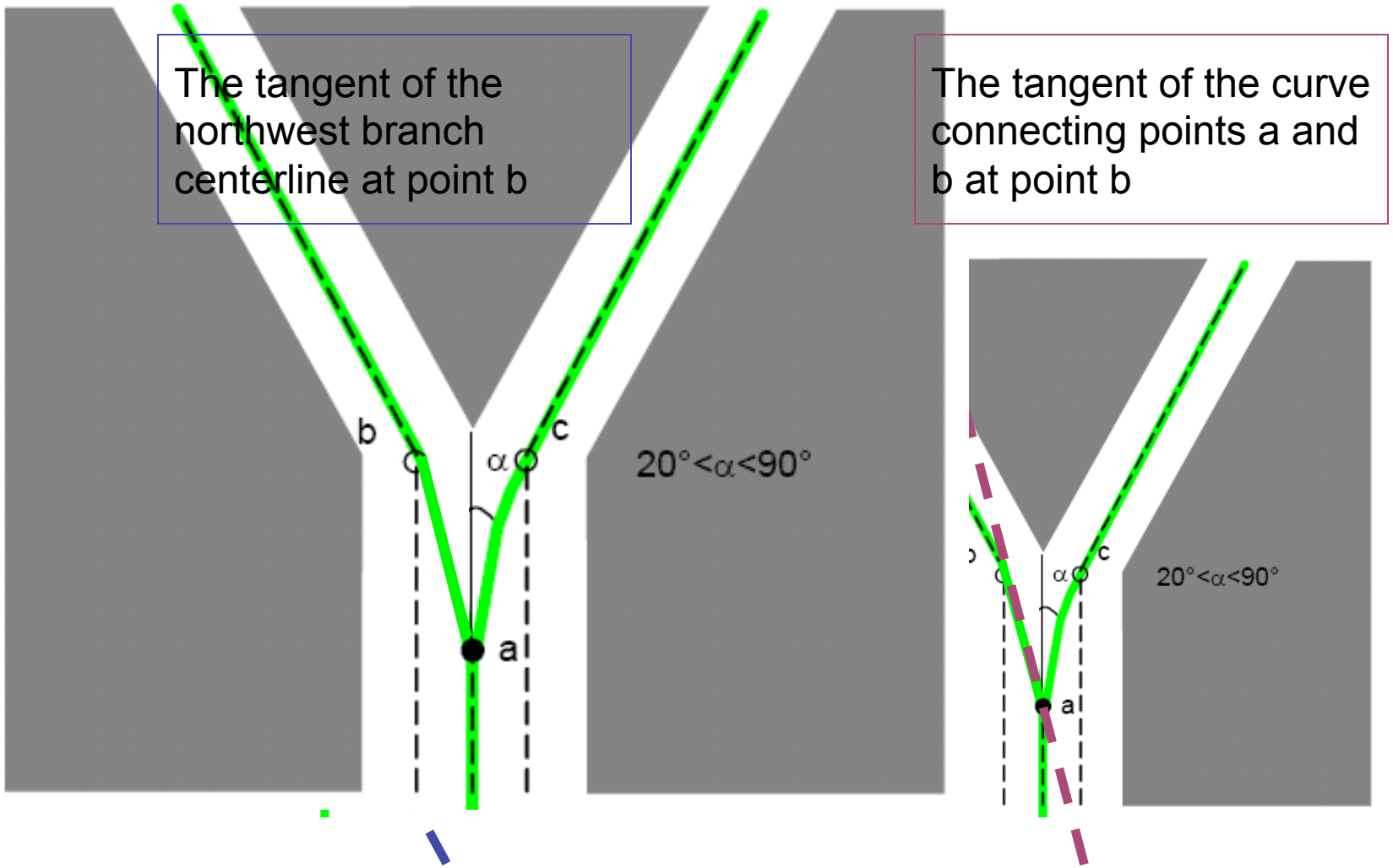


Section 5.3: Forks with legal separation

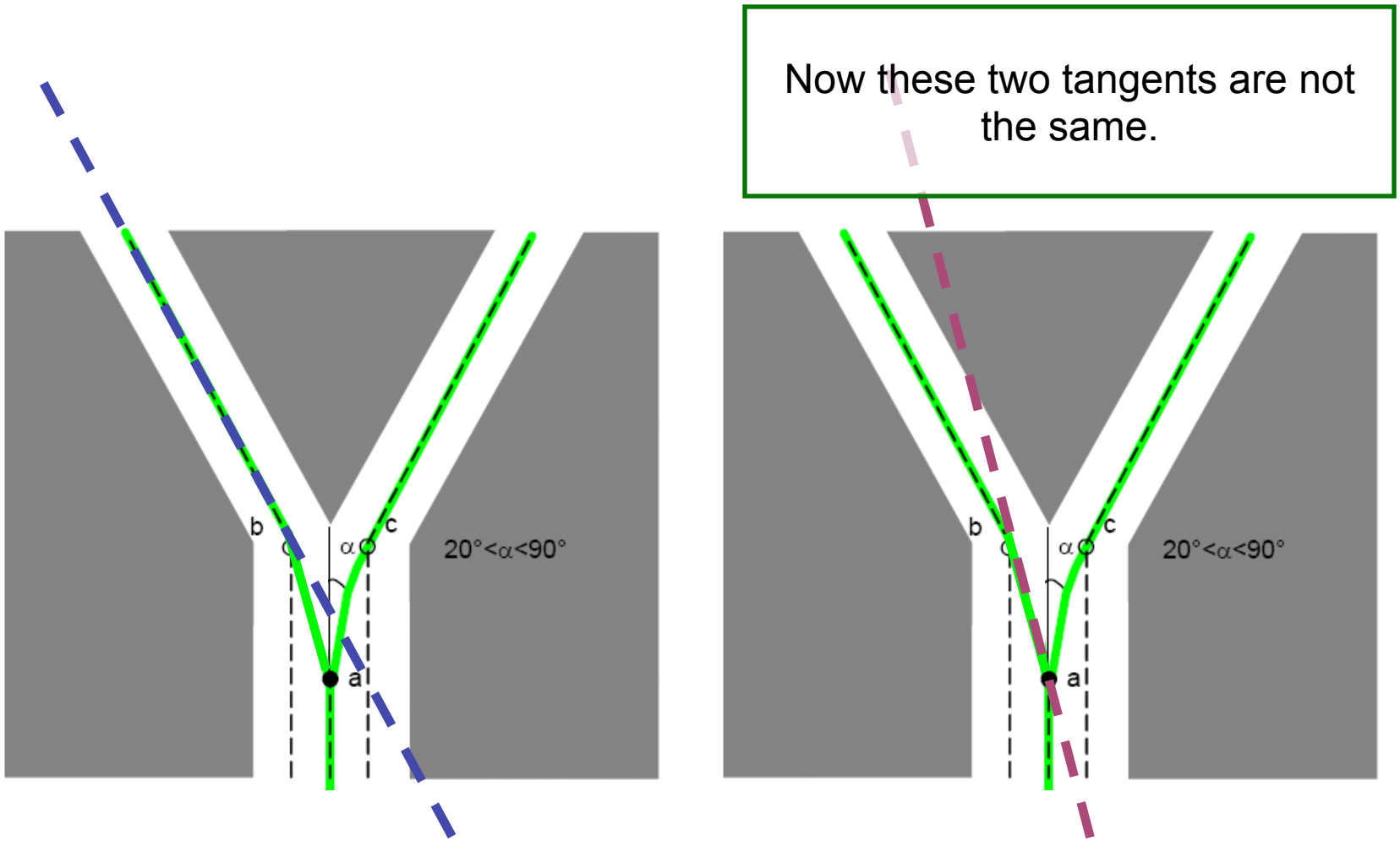


Let's look at a slightly different situation. Instead of a curve between points a and b, now there is a straight line.

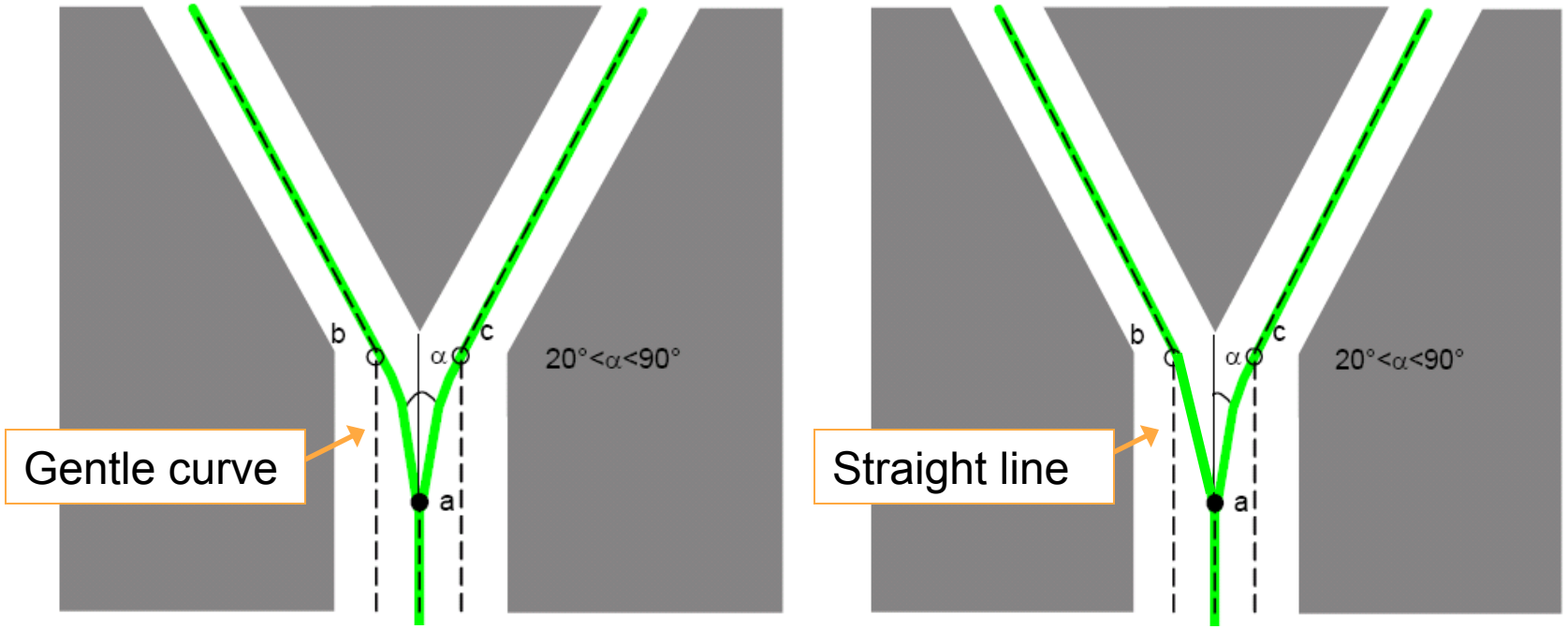
Section 5.3: Forks with legal separation



Section 5.3: Forks with legal separation



Section 5.3: Forks with legal separation



Compliant: A gentle curve that straightens out before meeting the centerline at point b.

Not compliant: A straight line that meets the centerline at point b.

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Figure 79: Forks with legal separation

The specification requires that a certain curve does not "change sign."

What does this mean?

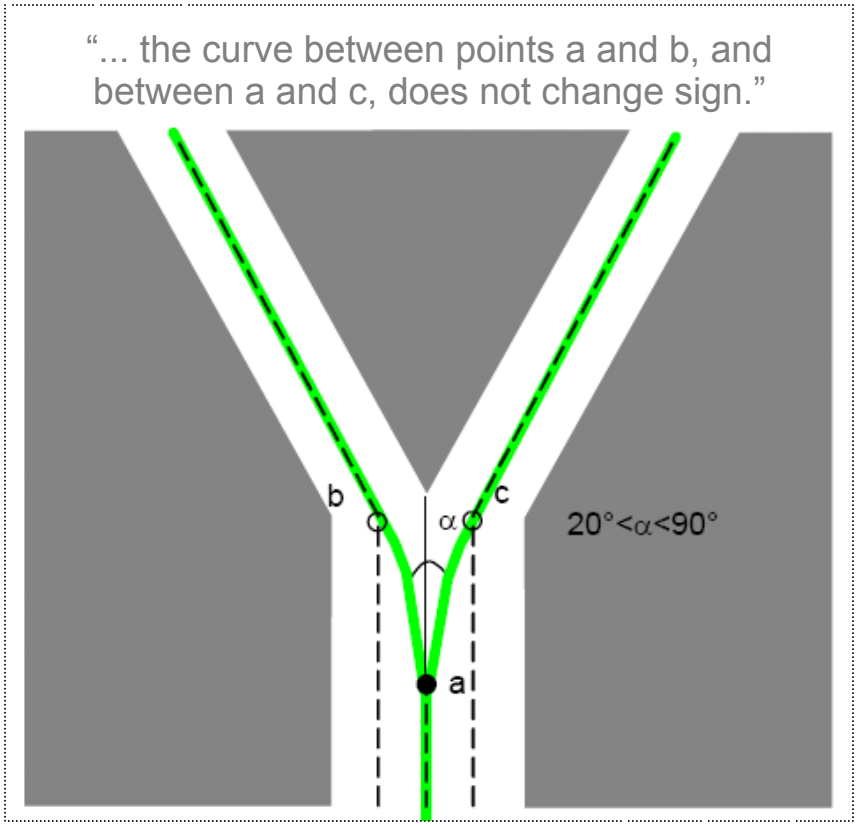
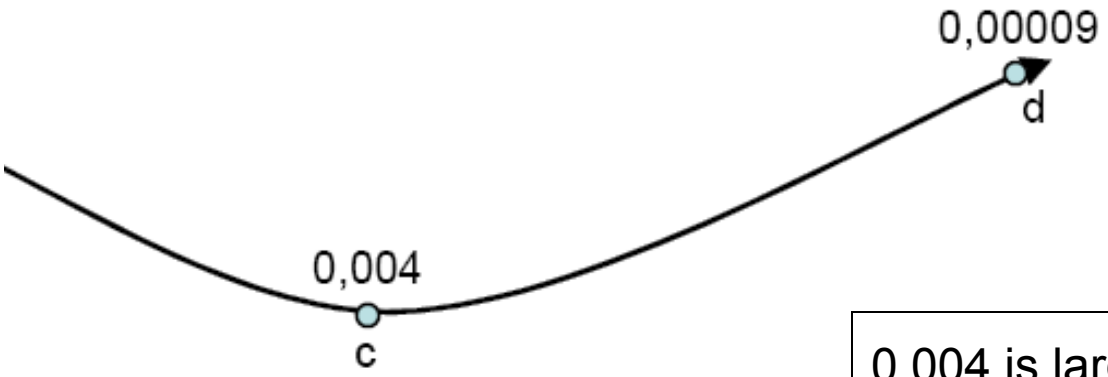


Figure 79: Forks with legal separation

Curvature is a number that describes how sharp a curve is. Larger numbers have sharper curves.



0.004 is larger than 0.00009, and it reflects a sharper curve.

Figure 79: Forks with legal separation

The “sign” of a curve refers to the positive or negative sign in front of the curvature value. (Positive sign is assumed when no plus or minus is displayed.)

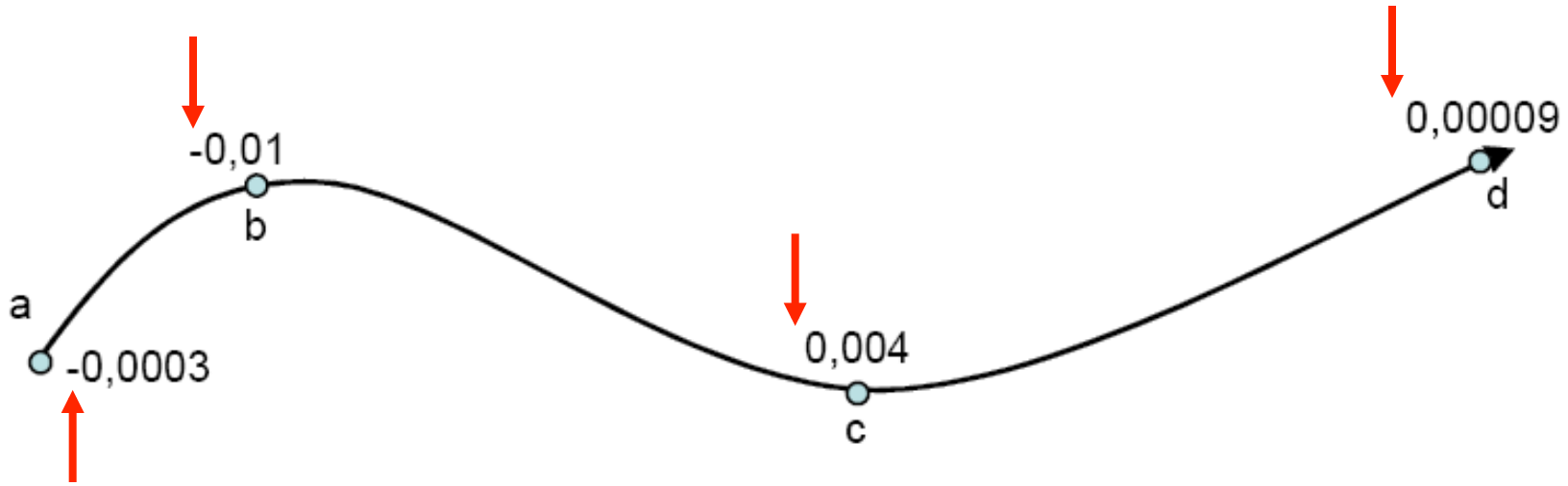


Figure 79: Forks with legal separation

Sample curves with positive sign	Sample curves with negative sign
0.004	- 0.0003
+ 0.004	- 0.01
0.00009	- 0.0415
+ 0.00009	

Figure 79: Forks with legal separation

Curves with a negative sign turn right and curves with a positive sign turn left. (“Right” and “left” relate to the direction of the Road Element.)

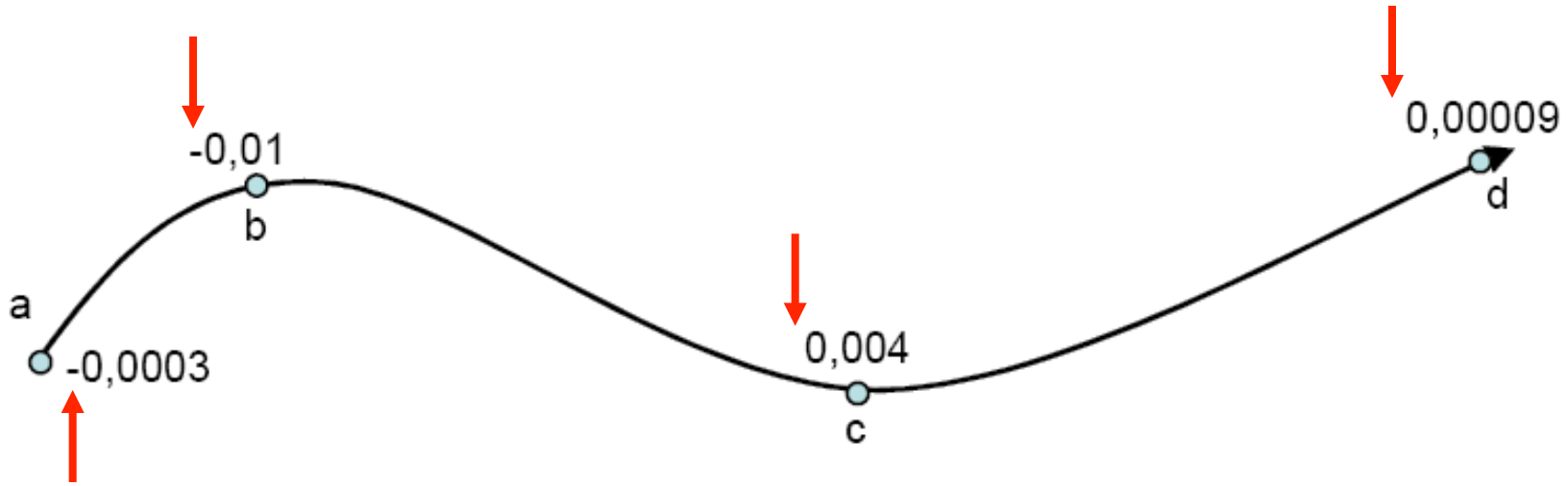


Figure 79: Forks with legal separation

We say that this curve “changes sign” because as you travel from the start node to the end node, the curvature number changes from negative to positive.

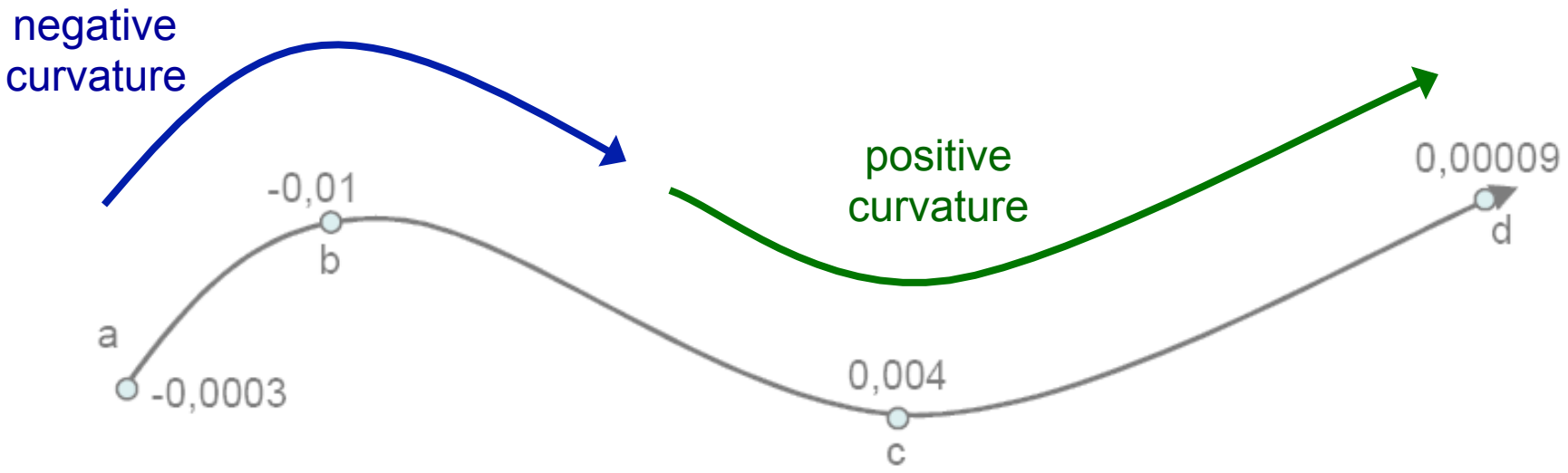
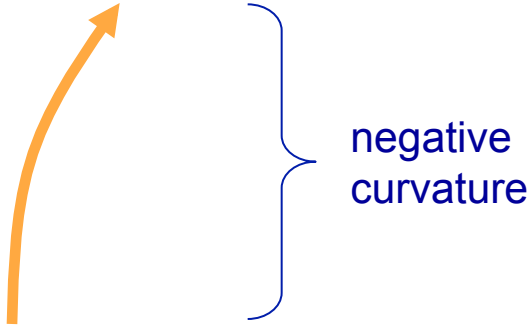


Figure 79: Forks with legal separation

This curve **does not change sign**.
It only bends in one direction.



This curve **changes sign**. It bends in more than one direction.

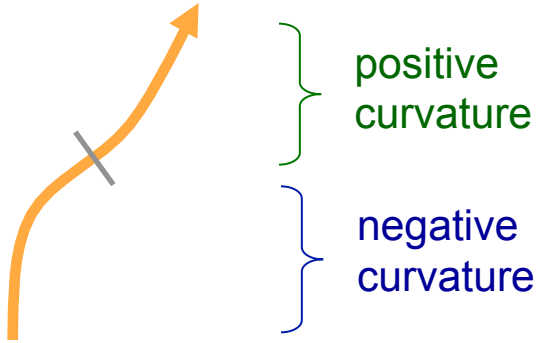
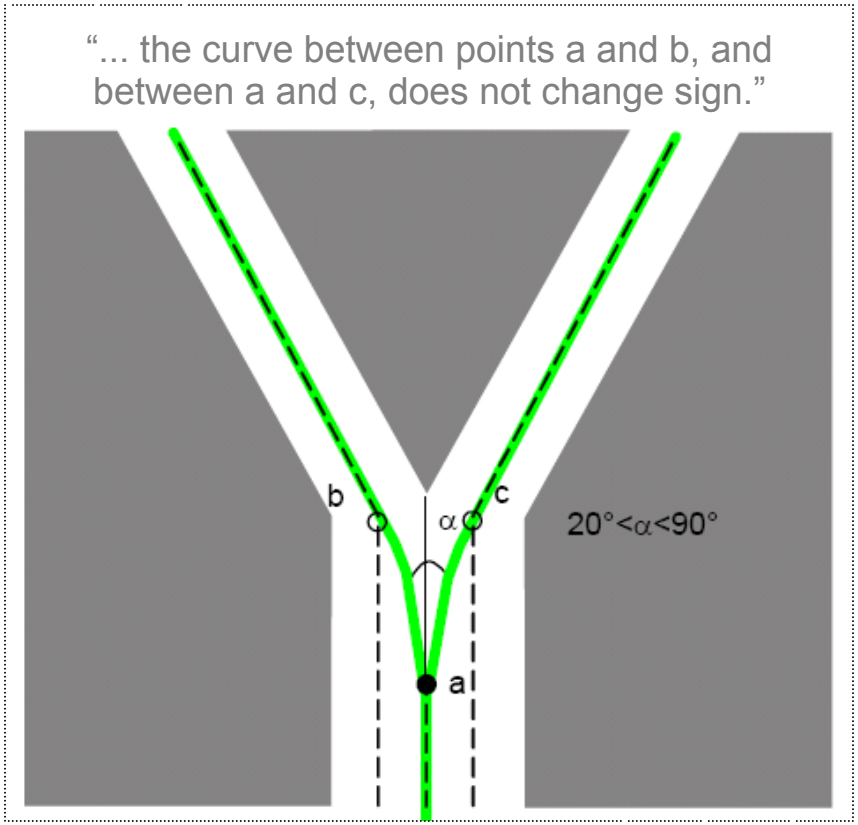


Figure 79: Forks with legal separation

The specification requires that a certain curve does not "change sign."

This means that the curve should only bend in one direction.



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