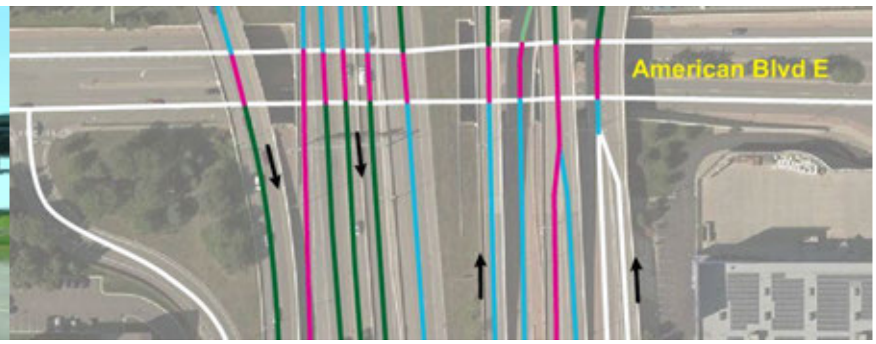
Metro Regional Centerlines Collaborative

Planarization & Routing Guide



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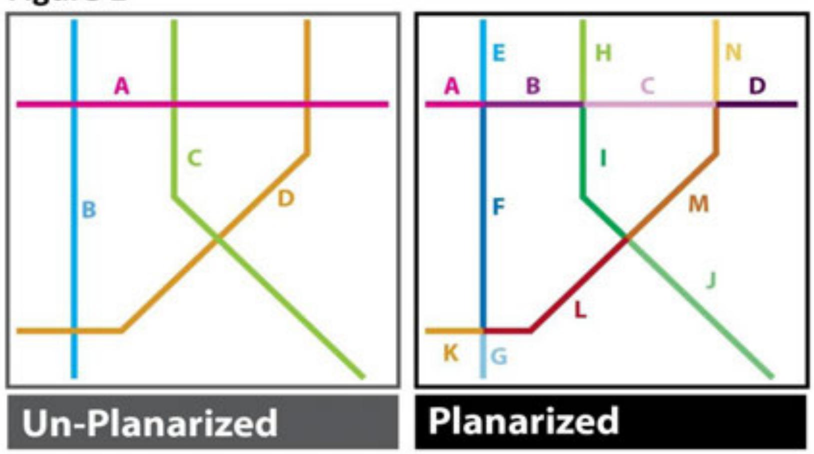
Purpose of this guide

The purpose of this guide is to provide a simple reference for agencies who are preparing their road centerline data for routing. The guide illustrates and describes common concepts related to preparing data for routing and provides a number of examples of planarization and attribution reflecting 'best practices' in producing a routable centerline dataset.

What is planarization?

Planarization is simply the process of splitting linear features at the places where they intersect other linear features. Each resulting linear segment gets its own unique ID and set of attributes; Figure 1 at right shows a very simplified example of un-planarized and the same geometry after it has been planarized.

Figure 1



There are tools in GIS software that can automate the geometry splitting process of planarization. In addition to simply splitting the line geometry, specific attributes are added to indicate how these segments connect (or do not connect) with one another. In the MRCC standard, these attributes are Elements 5.1 ('ELEV_FROM' [Elevation From]) and 5.2 ('ELEV_TO' [Elevation To]). Specific examples of how these are attributed are found later in this document.

Why are we planarizing our data for the centerline dataset?

One of the core goals for the MRCC dataset is to support routing functionality. Planarization of the data and populating the attributes identified in Elements 5.1 through 5.5 will meet that goal. Planarization of the geometry and populating of the supporting routing attributes is essential for being able to use the road centerline data effectively in the computer aided dispatch software in use by many of the participant counties and adds functionality for other emergency services and routing uses. The following pages contain maps, illustrations and accompanying narrative describing basic geometry and attribution treatments for preparing the data.

Basic Example: Grade-Separated Interchange

In **Figure 2** *(on page 4)* a common example of a grade-separated interchange is shown. This example shows the intersection of Interstate 35W and County Road D in northwestern Ramsey County where County Road D travels ***above*** Interstate 35W. The line geometry representing these roads in the geospatial data—while unable to show the lines in three dimensions—can be attributed to demonstrate that the county road is not directly routable to the interstate (except via the on and off ramps nearby).

The 'ELEV_FROM' attribute contains the elevation value from which the segment starts (for example: a value of '0' is at grade) and the 'ELEV_TO' attribute contains the elevation value of where the segment ends (a value of '1' is above grade, '-1' is below grade, etc.). These attributes follow the direction in which the segment was digitized.

Attributes in the **ELEV_FROM** and **ELEV_TO** columns as applied to the grade-separated interchange example in Figure 2 would be as follows:

	ELEV_FROM	ELEV_TO	*Notes*
Cyan segment	0	1	*County Road D rises from grade above Interstate 35W*
Magenta segment	1	1	*County Road D above Interstate 35W*
Green segment	1	0	*County Road D returns 'down' to grade*

As this road centerline geometry line work was digitized from east to west, the 'ELEV_FROM' and 'TO' attributes will follow suit. The **cyan segment** 'rises' from a '0' value (ELEV_FROM) to a '1' value (ELEV_TO) at the point where it hits the Interstate 35W segment to show:

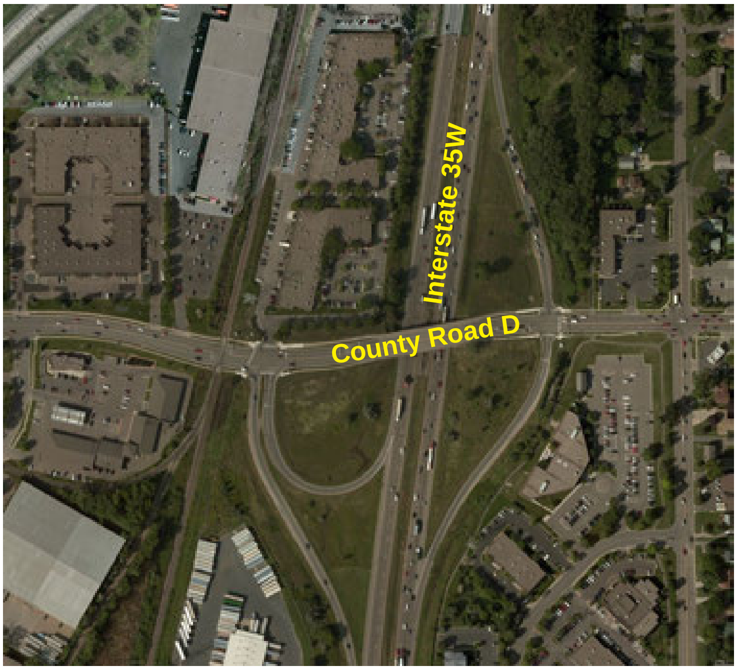
- It is *above* the interstate;
- It *does not connect* and *cannot be routed* to the interstate below;

The short **magenta segment** traverses the center of the bridge length between the two lanes of interstate below. Both the 'ELEV_FROM' and 'ELEV_TO' values of the **magenta segment** would be '1'; to show that it has no direct connection or routability to the segments of the interstate below it.

The **green segment** comes down from the bridge back to grade, having a 'ELEV_FROM' value of 1 and at 'ELEV_TO' value of '0'. Of note, all road lines shown in white carry an 'ELEV_FROM' and 'ELEV_TO' value of '0' (zero).

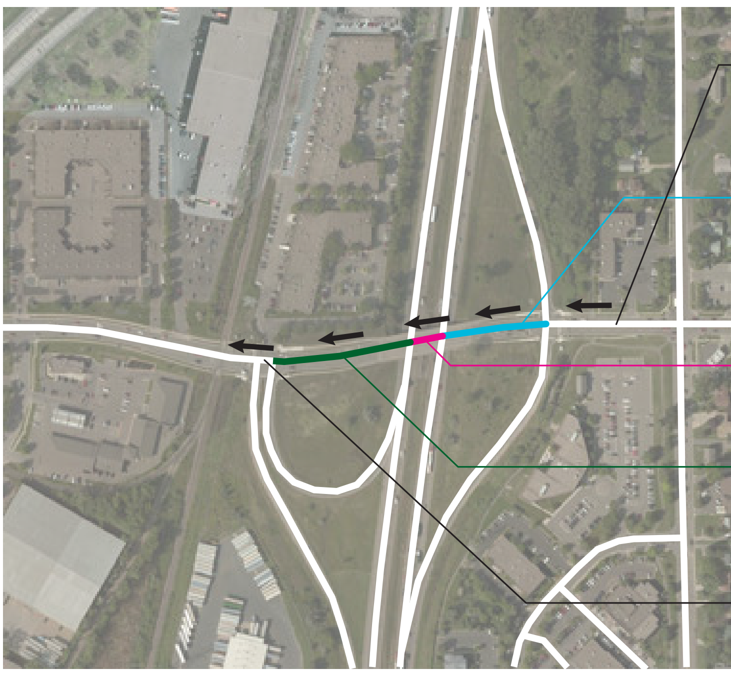
These concepts can be applied to more complicated situation as we will explore in the following examples.

Figure 2



In this example, the traffic flows both ways, however, the small black arrows *(in the lower map)* indicate the *direction in which these segments were digitized.*

The 'ELEV_FROM' attribute contains the elevation value at which the segment starts (a value of '0' is at grade, '1' is above grade, '-1' is below grade, etc.) and the 'ELEV_TO' attribute contains the elevation value of where the segment ends.



ELEV_FROM	ELEV_TO
0	0

ELEV_FROM	ELEV_TO
0	1

ELEV_FROM	ELEV_TO
1	1

ELEV_FROM	ELEV_TO
1	0

ELEV_FROM	ELEV_TO
0	0

Medium-Complexity Example: Cloverleaf

In **Figure 3** (on page 6) a more complex example is shown: the cloverleaf interchange of the intersection of State Highway 252 and Interstate 694 in north-eastern Hennepin County.

Similar to treatment of line work in Figure 2, each intersection creates a ‘break’ in intersecting lines and the attributes (-1, 0, 1, etc.) indicate how they connect (or don’t connect) in the vertical dimension.

In Figure 3, shown at **(a)**: the diagonal ramp coming in from the northwest goes ***beneath*** the northwestern cloverleaf ramp (which is ‘at grade’ and has a value of ‘0’) meaning the ramp needs a negative ‘ELEV_TO’ value (in this case ‘-1’) where it hits the clover leaf, a negative ‘ELEV_FROM’ value (again, ‘-1’) where it leaves clover leaf ramp, and a ‘0’ (at-grade) ‘ELEV_TO’ value where it rejoins the network at I-694.

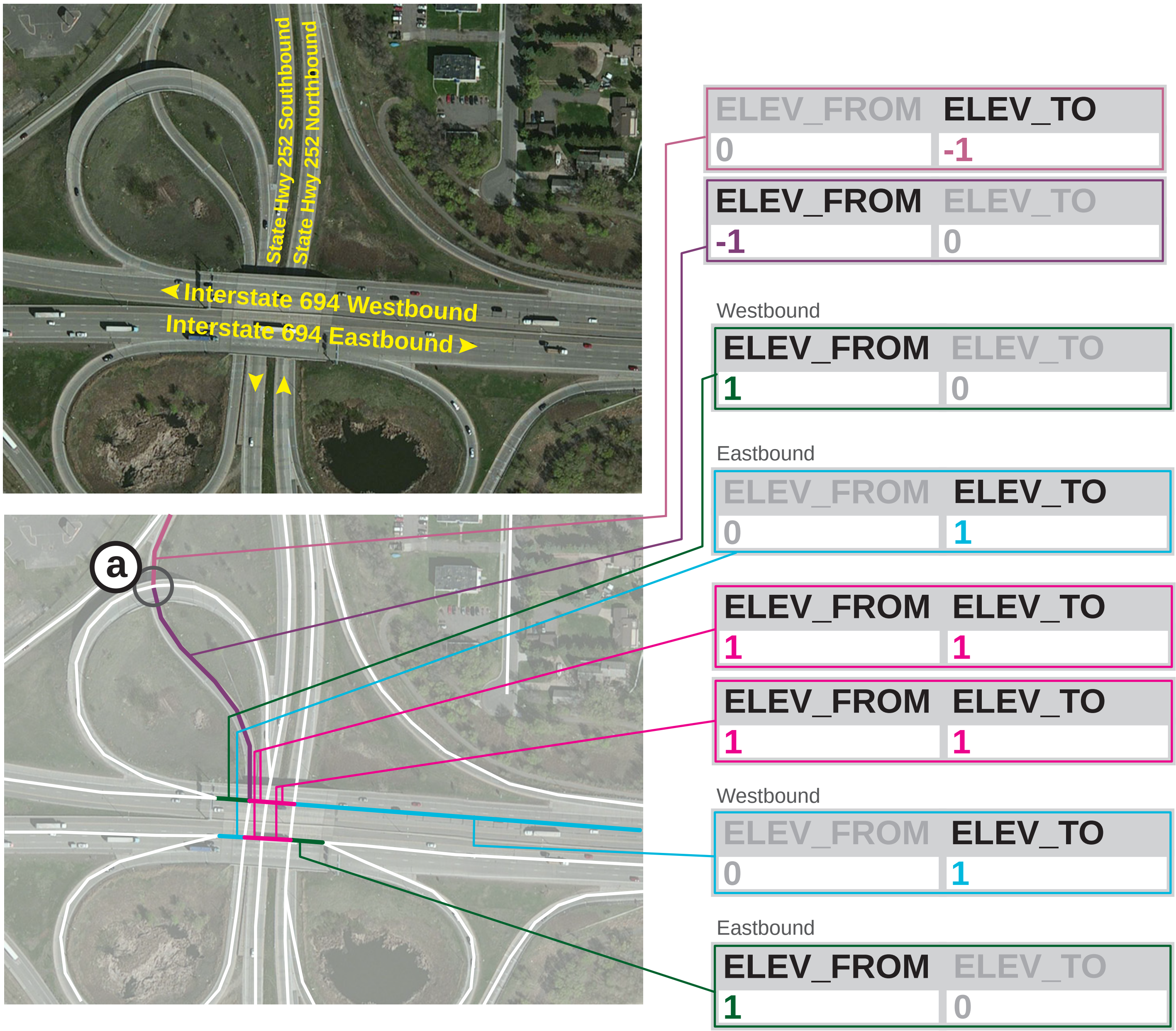
At the bottom of Figure 3 is a detail of the intersection. As shown in **(b)**, each intersection of lines results in a split, ***even if these segments are not connected vertically on the actual landscape.*** This ensures accurate routing ability between features with like ‘ELEV_FROM’ and ‘ELEV_TO’ attributes.

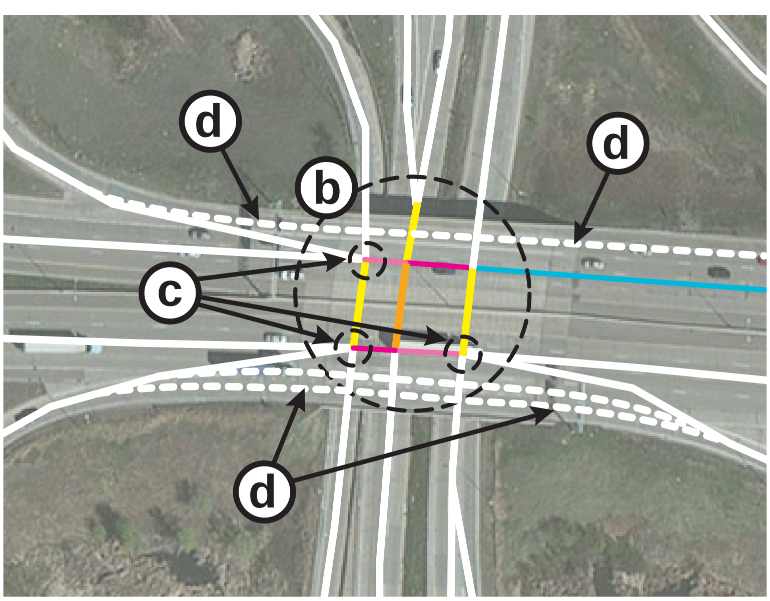
On-ramps coming in at an angle can be connected (‘snapped’) to the intersections of the segments they connect to or are close to; as shown in example **(c)**. While sacrificing a bit of accuracy, this can greatly reduce the number of small remnant segments that would potentially be created.

As shown in example **(d)**, the white dashed lines indicate the paths of the actual physical ramps however, the priority of creating data for routing is to ensure the segments connect in the model to facilitate routing connectivity not to spatially depict the exact physical ramp position.

The trade-offs of modification of linear features topology *(as shown in examples* ***(c)*** *and* ***(d)*** *in Figure 3)* to facilitate modeling and maintenance are more fully discussed and illustrated on pages 9 and 10 and reference Figures 5 and 6.

Figure 3





(a) *Roads below grade will use negative values;*

(b) *Each intersection of lines creates separate segments;*

(c) ***Best practice:***
On/off ramps should connect to minimize small segments

(d) ***Best practice:***
Connectivity of the ramp to the main road is of more importance for routing and maintenance than the accurate representation of the shape of the ramp;

Complex System Example

In **Figure 4** *(on page 8)* a more complex example is shown containing various on-and-off ramps near the Mall of America, in the City of Bloomington, which aligns and connects State Highway 77 with Lindau Lane and the adjacent frontage roads. As with the prior figures and examples, each intersection creates a break in intersecting lines and the integer attributes (-1, 0, 1, etc.) are used to indicated connectivity.

The example shown in Figure 4 presents a complex set of circumstances, which are easily handled by correctly assigning integers in the 'ELEV_FROM' and 'ELEV_TO' fields. A unique case, shown at the top of the page 7 at **(e)**, shows a northbound ramp that goes ***over*** American Boulevard East and then goes ***beneath*** another ramp, which would be attributed in this way:

	ELEV_FROM	ELEV_TO	*Notes*
Magenta segment	1	1	*Northbound ramp goes over American Blvd East*
Light green segment	1	-1	*Ramp then goes beneath adjacent ramp*
Violet segment	-1	0	*Ramp returns to grade*

At **(f)** the east-bound off-ramp connecting to Lindau Lane is ***above*** the west-bound on-ramp coming from Lindau Lane, and both of these ramps are ***above*** Highway 77; all three roadways are effectively stacked atop one another. The west-bound ramp that turns south on the west side of Highway 77 would be attributed in this way:

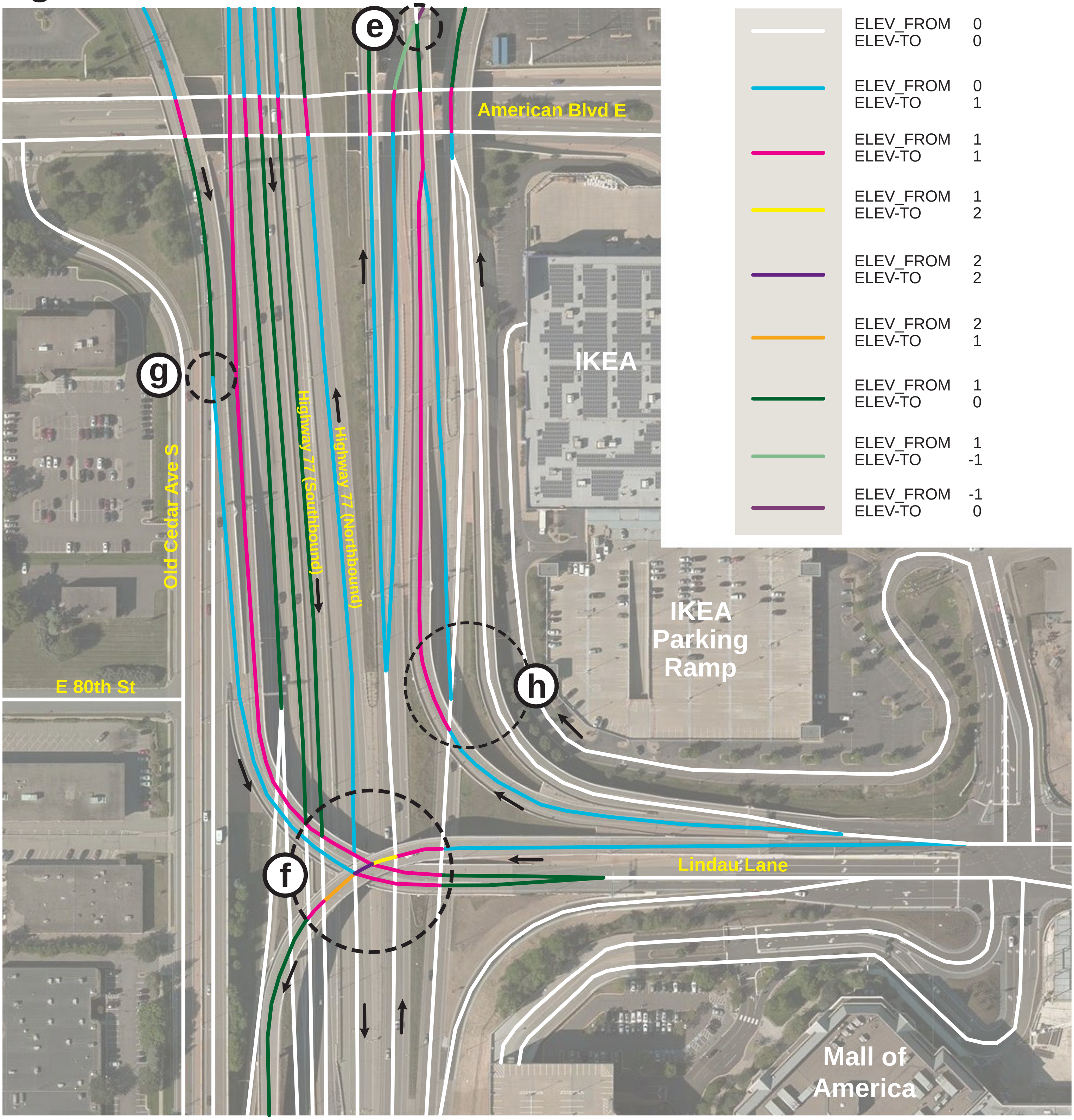
West bound ramp segments	ELEV_FROM	ELEV_TO	*Notes*
Cyan segment (long)	0	1	*Westbound ramp rises to go over Hwy 77*
Magenta segment (short)	1	1	*Westbound ramp is above Hwy 77*
Yellow segment (short)	1	2	*Westbound ramp over eastbound ramp and Hwy 77*
Purple segment (short)	2	2	*Westbound ramp over eastbound ramp and Hwy 77*
Orange segment (short)	2	1	*Westbound ramp descending*
Magenta segment (short)	1	1	*Westbound ramp above 'at grade' ramps below*
Dark green segment (long)	1	0	*Westbound ramp return down to grade*

Other examples illustrated on Figure 4:

At **(g)**, the southbound split becomes a ramp *(**cyan**, going from 'grade ['0'] up one level ['1'])* and a frontage road *(remaining at grade ['0'] shown in white).*

At **(h)**, the various northbound ramps are attributed using the same method: frontage roads remaining at grade '0', on-ramps rising up to '1', and so on.

Figure 4



e *Unusual configuration*

f *Ramp rising above another ramp and above the divided highway*

g *Split where one route becomes a ramp, and the other remains at grade*

h *Off-ramp, on-ramp and frontage road*

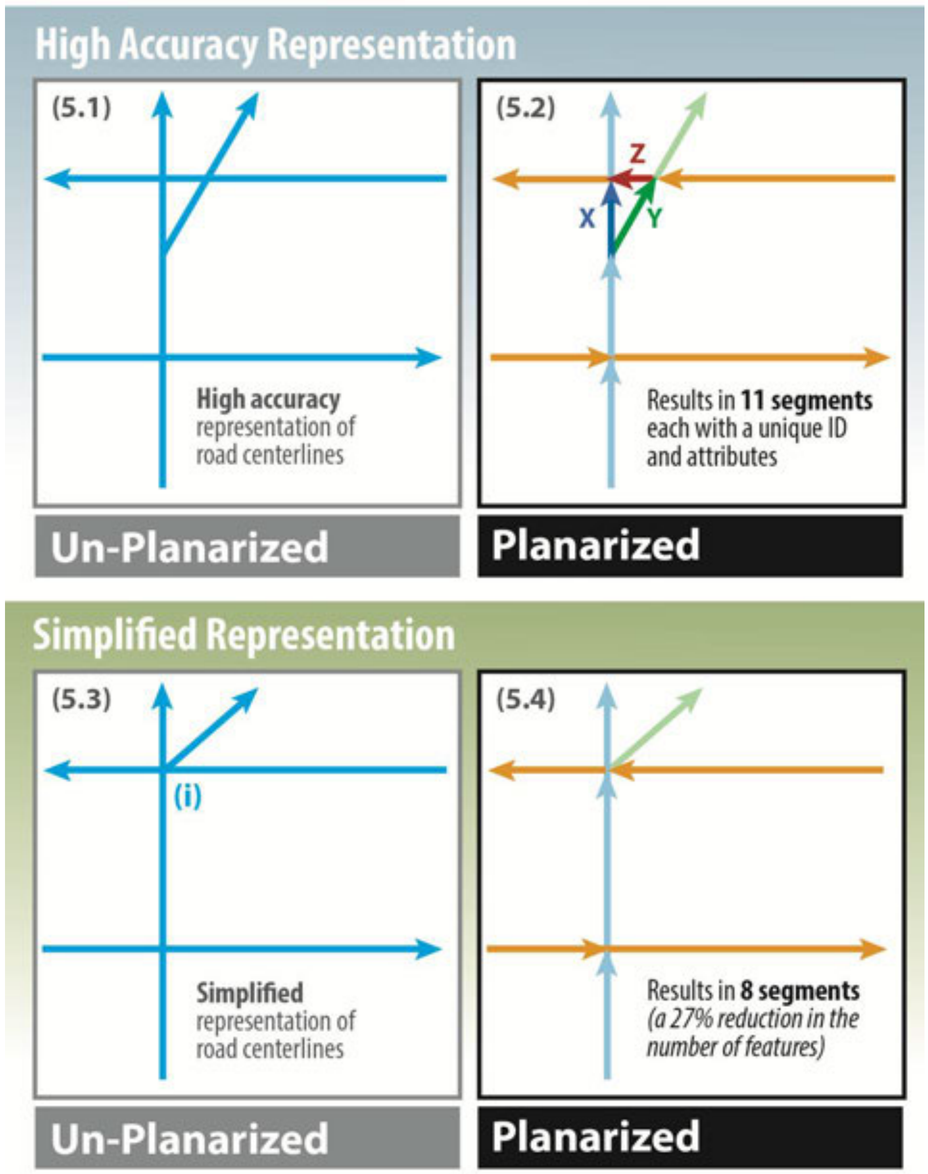
Changing Topology for Simplicity of Modeling and Maintenance

As discussed in the 'Cloverleaf Example' on pages 5 and 6, there is often a trade-off between ***highly accurate road centerline representations*** and the ***complexity of the final planarized product.***

Small adjustments in where, and how, road segments are represented can result in significant reductions in the number of segments when planarized. This is particularly true in the case of roads that do not intersect at grade.

In **Figure 5**, moving the representation of where the under-passing road begins can reduce the number of small segments that need to be handled. When the lines in **5.1** are planarized, three small segments result (segments x, y, and z; shown in **5.2**); each of which needs to be assigned an ID and given attributes.

Figure 5



By simplifying the geometry—in this example: moving the diagonal ramp to start ***at*** the intersection, as shown at **(i)** in **5.3**—the resulting planarization (shown in **5.4**) results in fewer segments that are more easily managed and attributed.

Each agency producing centerline data needs to determine which technique will work best to capture, depict and attribute its own road features.

Changing Topology for Simplicity in Routing

There is also a trade-off to be had regarding highly accurate road centerlines and simplicity for routing purposes.

Figure 6 illustrates two treatments of road segment geometry at an intersection in the City of St. Paul.

In 6.1, the segments are a highly accurate representation of the actual roadway. However, this geometry would likely provide confusing routing instructions for a driver who wanted to travel from southbound Gotzian Street to westbound Conway Street.

The routing system would likely give the following directions: ***"Travel south on Gotzian, turn right on Johnson Parkway, then turn right on Conway."*** *(as illustrated by the pink, dashed line in 6.1)*

The modified geometry shown in 6.2, simplifies the intersection connections to facilitate clearer routing; our example would now read: ***"Travel south on Gotzian Street, turn right on Conway Street."*** *(as illustrated by the pink dashed line in 6.2)*

Each agency producing centerline data needs to determine which representations will best balance its need for accurate geometric representations of the streets versus facilitating routability in its system.

Figure 6