Integrated Vehicle-to-Infrastructure
Prototype (IVP)

V2I Hub Map XML Input File Instructions

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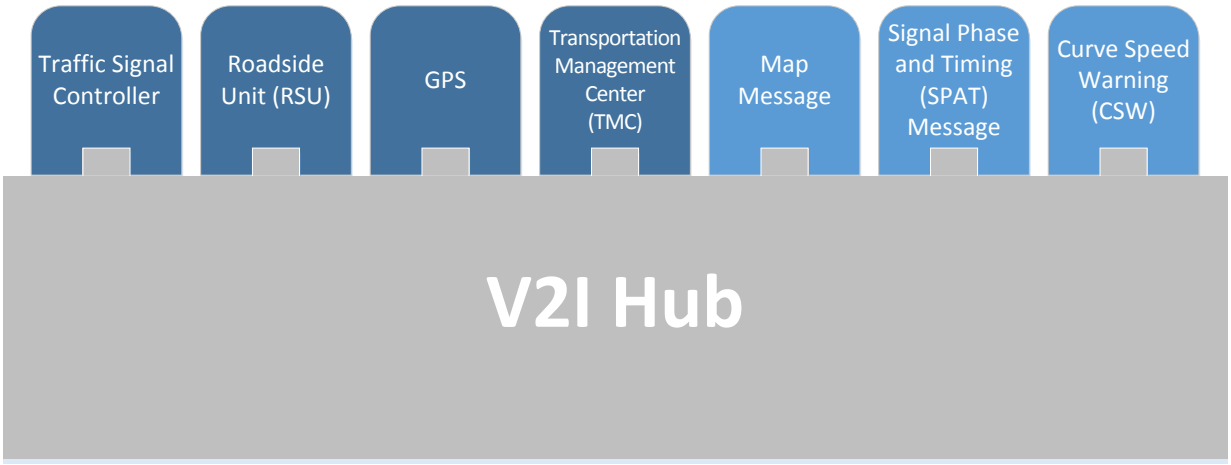
March 2017



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Introduction

V2I HUB

The Integrated Vehicle-to-Infrastructure Prototype (IVP), called V2I Hub, is part of USDOT's Vehicle-to-Infrastructure Program and was developed to support jurisdictions in deploying V2I technology by reducing integration issues and enabling use of their existing transportation management hardware, and systems. V2I Hub is a software platform that utilizes plugins to translate messages between different devices and run connected vehicle safety applications on roadside equipment.

DOCUMENT PURPOSE

The purpose of this document is to outline instructions for developing the Map XML input file describing the infrastructure geometry used by V2I Hub in developing the SAE J2735-201509 MAP message.

TARGET AUDIENCE

The target audience for this document is technical personnel familiar with the infrastructure and the eXtensible Markup Language. The end user will need familiarity with connected vehicle technology.

PREREQUISITES

These instructions utilize a Map Creation application available from Battelle.

Instructions

SET UP INITIAL MAP ENVIRONMENT IN 'GOOGLE EARTH PRO'

- Locate the desired intersection with a specific reference point (i.e., specific latitude and longitude).
- Add a new folder to 'My Places' in the left side panel of Google Earth (example: E_30th_Street_2nd_Avenue_intersection)
- Add a placemark with the specific latitude and longitude in the folder created.
- Term this placemark as 'Reference Point'.
- Add the desired vehicle lanes starting from West lanes and going counter clockwise by selecting the 'Add Path' icon.
- Add all the ingress lanes in counter clockwise direction (going away) from center line (West ingress lanes 2 & 3 were drawn counter clockwise based on lane 1 in Figure 3).
- Note: going away from the center line direction will change according to the current lane group that is being mapped.
    - West lane group-> from center line going South,
    - South lane group-> from center line going East,
    - East lane group-> from center line going north, and
    - North lane group-> from center line going West.
- Now that all ingress lanes are mapped, add all the egress lanes in clockwise direction from center line.
- Assign all the added paths by their lane number in the properties window.
- Once all egress lanes are mapped, determine if there are any pedestrian crosswalks present in the image and label them starting with the pedestrian crosswalk closest to the west most lane group going counter clockwise. Start the numbering at the integer 101, and monotonically increase until all pedestrian crosswalks have been exhausted.
- Once all pedestrian lanes are mapped, determine if there are any barriers present in the image and label them starting with the barrier closest to the west most lane group going counter clockwise. Start the numbering at the integer 201 and increase until all barrier lanes have been completed.
- Once the intersection mapping is complete on the image, create a Microsoft Excel spreadsheet comprised of lane attributes, geometry, connections and signal groups as shown in Figure 1.

Lane	Width	Attribute logic	Lane type	Attribute Binary Value	Attribute Decimal Value	Connection#1	Connection Type	Maneuver bit	Signal Group	Connection#2	Connection Type	Maneuver bit
1	268	left only	Vehicle	0000 0000 0100 0100	68	19	left	2	3			
2	268	straight	Vehicle	0000 0000 0000 0010	2	15	straight	1	2			
3	268	straight	Vehicle	0000 0000 0000 0010	2	16	straight	1	2			
4	258	straight	Vehicle	0000 0000 0000 0010	2							
5	258	straight	Vehicle	0000 0000 0000 0010	2							
6	258	straight	Vehicle	0000 0000 0000 0010	2							
7	281	left only	Vehicle	0000 0000 0100 0100	68	4	left	2	1			
8	133	straight	Bike lane	0001 0000 0000 0010	4098	18	straight	1	1			
9	271	straight	Vehicle	0000 0000 0000 0010	2	19	straight	1	1			
10	495	straight	Vehicle	0000 0000 0000 0010	2	20	straight	1	1	21	straight	1
11	331	straight	Vehicle	0000 0010 0000 0010	514	22	straight	1	1			
12	265	straight	Vehicle	0000 0000 0000 0010	2	4	straight	1	3			
13	265	Straight and right	Vehicle	0000 0000 0100 1010	74	5	straight	1	3	20	right	4
14	265	right only	Vehicle	0000 0000 0100 1000	72	21	right	4	3			
15	320	Straight	Vehicle	0000 0000 0000 0010	2							
16	330	Straight	Vehicle	0000 0000 0000 0010	2							
17	280	reserved	Parking	0000 0000 0000 0010	2							
18	130	Straight	Bike lane	0001 0000 0000 0010	4098							
19	320	Straight	Vehicle	0000 0000 0000 0010	2							
20	320	Straight	Vehicle	0000 0000 0000 0010	2							
21	320	Straight	Vehicle	0000 0000 0000 0010	2							
22	320	Straight	Vehicle	0000 0000 0000 0010	2							
101	720	Straight	Pedestrian	0000 0000 0000 0011	3				5			
102	470	Straight	Pedestrian	0000 0000 0000 0011	3				4			
103	470	Straight	Pedestrian	0000 0000 0000 0011	3				4			
104	780	Straight	Pedestrian	0000 0000 0000 0011	3				5			
105	1678	Straight	Pedestrian	0000 0000 0000 0011	3				4			

Figure 1. Excel Sheet with Lane Attributes, Width, Connections, and Signal Groups

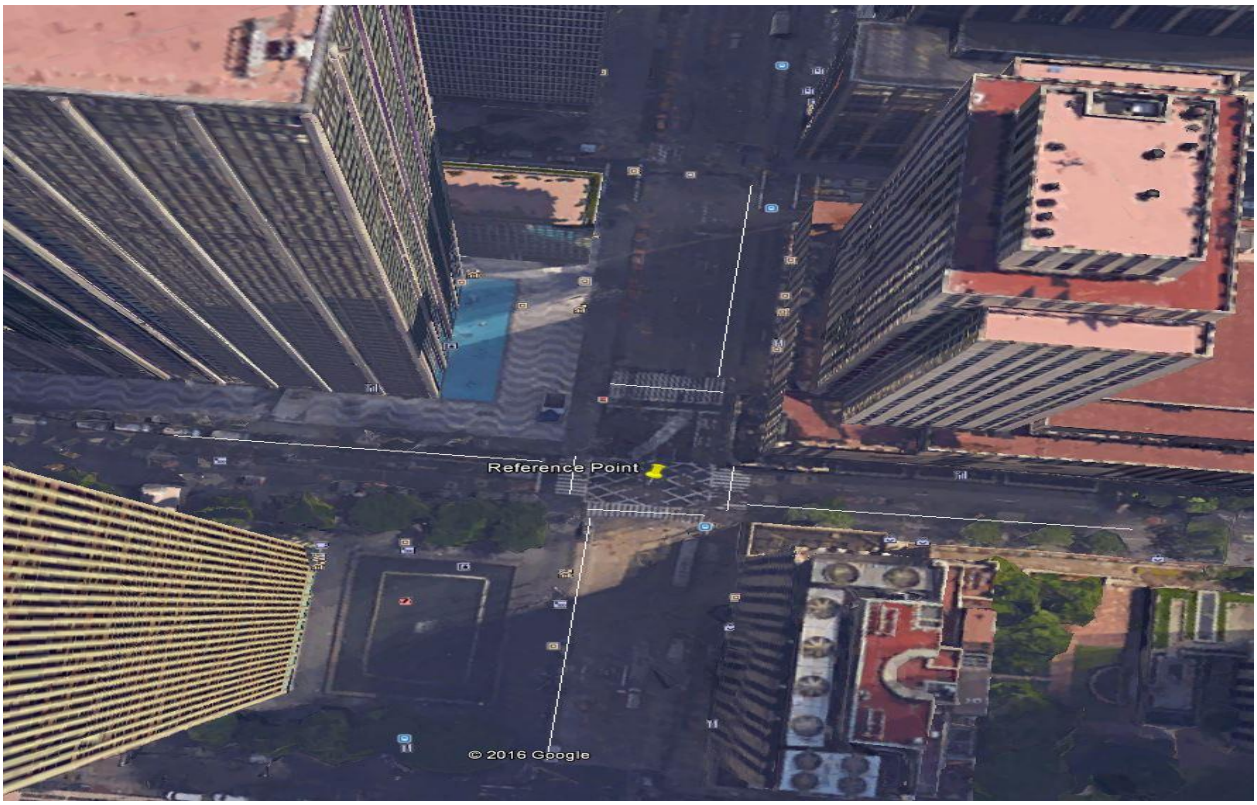

Figure 2. Google Earth Pro Picture Depicting Added Vehicle Lanes (Add Path) and Pedestrian Crosswalks

In Figure 2, four (4) vehicle lanes and four (4) lanes designated as pedestrian crosswalks were added. Once a vehicle lane is added, lanes parallel to it with the same vehicle type (e.g., vehicle, bus only, or bike lane) and geometry can be added as computed lanes, reducing the message size.

EXPORT KML FILE FROM GOOGLE EARTH PRO

After adding all the lanes (vehicle, pedestrian, barrier) in 'Google Earth Pro', save using the option 'Save place as' in .kml format.

IMPORTING KML MAP FILE INTO MAP CREATOR APPLICATION

Open this .kml file in the Map Creator (MAP Plugin Input Creator.exe) application to confirm the placement of the mapped lanes. In the Map Creator application use the File->Load KML menu option.

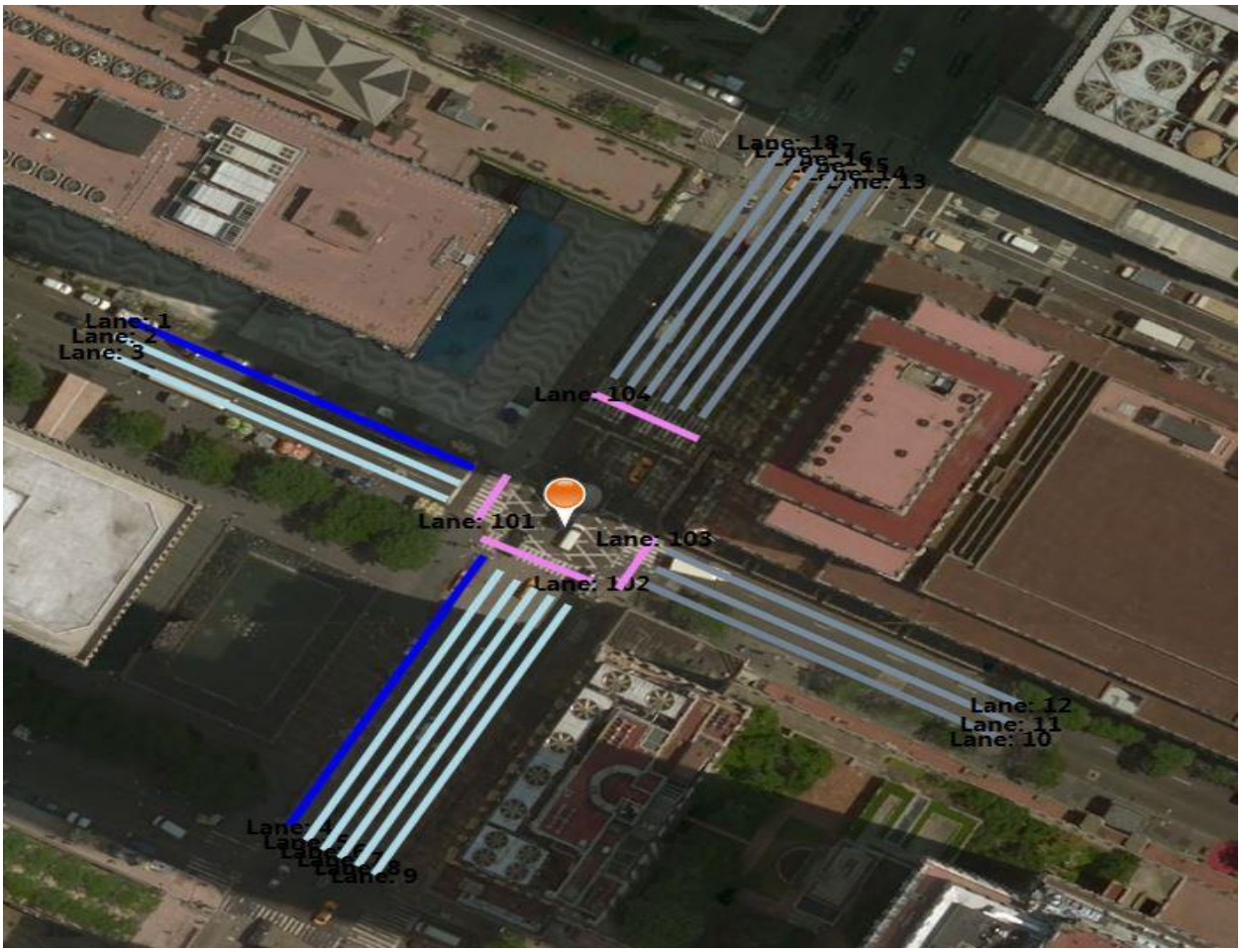

Figure 3. Ingress and Egress Computed Lanes Added on All Approaches Using Map Creator Application

Note: In some scenarios, lanes drawn in Google Earth Pro do not fall exactly on the same place when opened in the Map Creator application, which uses Bing Maps instead of Google Maps.

EXPORTING XML MAP FILE USING MAP CREATOR APPLICATION

Convert the KML file in Map Creator to .xml format by selecting the File->Save XML menu option. The .xml file contains the coding of the lanes in .xml format. A sample .xml code is shown below.

SAMPLE .XML CODE FOR A VEHICLE LANE

```
</Lane>
<Lane Number="3">
<Type>Vehicle</Type>
<Attributes>4098</Attributes>
<Width>110</Width>
<Nodes>
<Node Number="1">
<Eastern>-232</Eastern>
<Northern>72</Northern>
<Elevation>6</Elevation>
</Node>
<Node Number="2">
```

```
<Eastern>-1005</Eastern>
<Northern>562</Northern>
<Elevation>-3</Elevation>
</Node>
</Nodes>
<Connection>
<Lane Number>13</LaneNumber>
<Maneuver>1</Maneuver>
<SignalGroup>2</SignalGroup>
</Connection>
<Connections />
<ReferenceLane />
```

EXPLANATION OF THE .XML CODE

1. `<Lane Number="3">` refers to the number designated to the lane created.
2. `<Type>Vehicle</Type>` refers to the lane type (Vehicle, Pedestrian, Bike, or Sidewalk).
3. `<Attributes>4098</Attributes>` refers to the attribute given to the lane based on its navigational maneuvers, lane restrictions and other characteristics as follows:

   Motorized Vehicle and Computed Lane Attributes

   The attributes for the motorized vehicle and computed lane types define the allowed navigational maneuvers and other restrictions as follows.

   ```
   0 (LSB) Lane provides a two-way travel
   1  Straight maneuver permitted
   2  Left turn maneuver permitted
   3  Right turn maneuver permitted
   4  Yield
   5  No U-turn
   6  No turn on red
   7  No stopping
   8  HOV lane
   9  Bus only lane
   10 Bus and taxi only lane
   11 Shared two-way left turn lane
   12 Bike lane
   13-15   Reserved
   ```

   Pedestrian Lane Attributes

   The attributes for a pedestrian lane define the type of crosswalk, bicycle-crossing, or other non-motorized lane as follows.

   ```
   0 (LSB) Lane provides a two-way travel
   1  Pedestrian crosswalk
   2  Bicycle crossing
   3  Railroad track is present
   4-15    Reserved
   ```

   Barrier Lane Attributes

   The attributes for barrier lanes are listed below. A barrier is any object, which normally vehicle traffic cannot transverse as follows.

   ```
   0 (LSB) Median
   1  White line
   2  Stripped lines
   3  Double-stripped lines
   ```

```
4  Traffic cones
5  Construction barrier
6  Traffic channels
7  No curbs
8  Low curbs
9  High curbs
10 HOV, do not cross
11 HOV, entry allowed
12 HOV, exit allowed
13-15   Reserved
```

Logic Behind Calculation of Attributes

All the lane attributes are a 16 bit code with 1 being highest priority and 0 being least priority.

Example-1:

In the .xml code sample, lane#3 is a bike lane that provides a straight maneuver.

```
1   0    0 (LSB)     Lane provides a two-way travel
2   1    1      Straight maneuver permitted
4   0    2      Left turn maneuver permitted
8   0    3      Right turn maneuver permitted
16  0    4      Yield
32  0    5      No U-turn
64  0    6      No turn on red
128      0      7      No stopping
256      0      8      HOV lane
512      0      9      Bus only lane
1024     0      10     Bus and taxi only lane
2048     0      11     Shared two-way left turn lane
4096     1      12     Bike lane
```

The attribute value is 00001000000000010 in binary format. Convert this binary value to a decimal value as shown below:

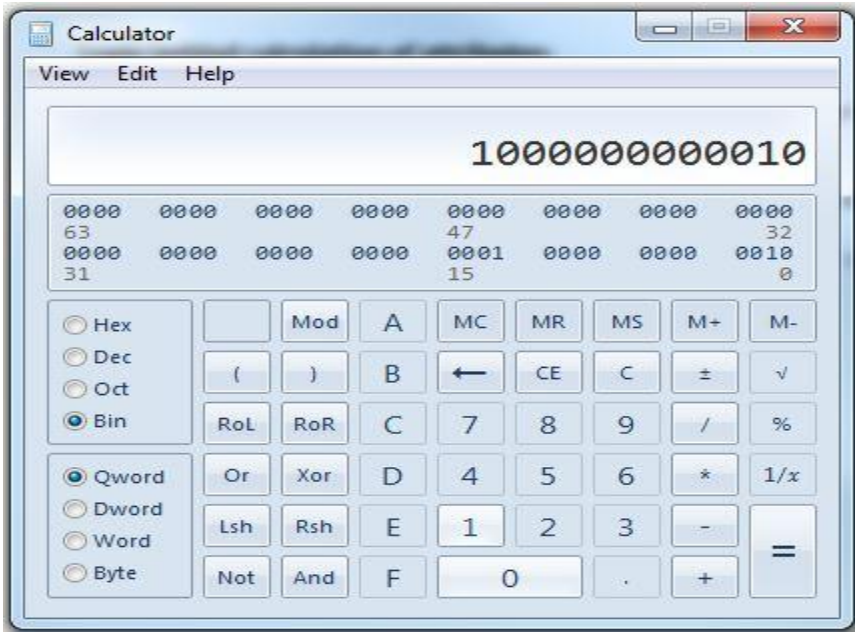

Figure 4. Attribute Binary Value Keyboarded in Calculator

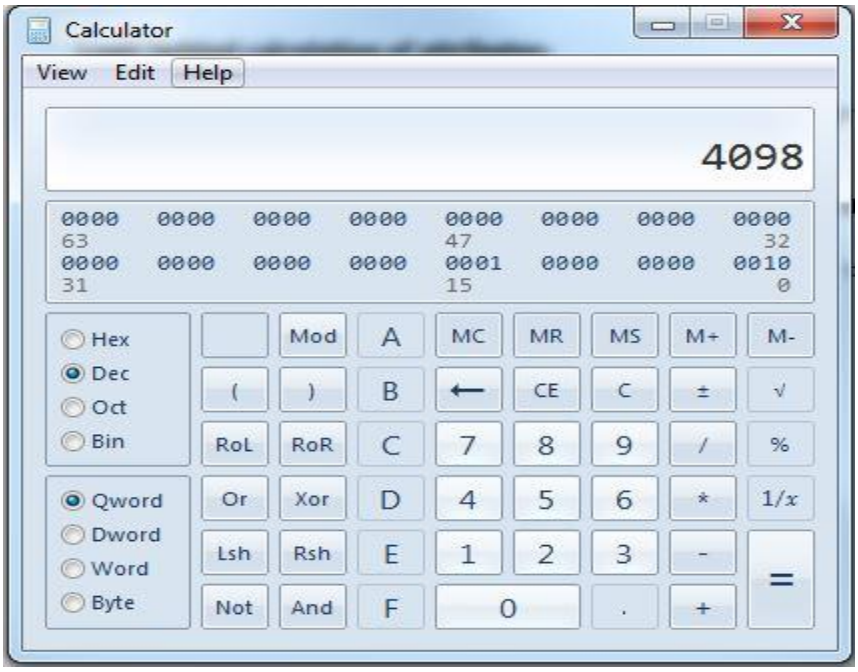

Figure 5. Attribute Decimal Value Converted by Calculator

As shown in Figure 5, 4098 is the decimal equivalent for the bike lane in lane#3.

Example-2:

A pedestrian crosswalk providing two-way straight access.

```
1  0 (LSB)    Lane provides a two-way travel
1  1    Pedestrian crosswalk
0  2    Bicycle crossing
0  3    Railroad track is present
0  4-15 Reserved
```

Here, the attribute value is 0000000000000011 in binary format. The converted decimal value would be 3.

4. `<Width>110</Width>` refers to width of the specific lane. (Use the Google Earth Pro ruler tool to measure the width of each lane).
5. `<Node Number="1">` refers to node#1 of the specific lane.
6. `<Eastern>-232</Eastern>` refers to the distance of Node#1 from the 'Reference Point' in East (+) or West (-) direction. (Use Google Earth Pro ruler tool to measure distance in East or West direction).
7. `Northern>72</Northern>>` refers to the distance of Node#1 from the 'Reference Point' in North (+) or South (-) direction. (Use Google Earth Pro ruler tool to measure distance in East or West direction).
8. `<Node Number="2">` refers to Node#2 of the specific lane.
9. `<Eastern>-1005</Eastern>` refers to the distance of Node#2 from 'Node#1' in East (+) or West (-) direction.
10. `<Northern>562</Northern>` refers to the distance of Node#2 from the 'Node#1' in North (+) or South (-) direction.

11. `<Elevation>6</Elevation>` refers to the difference in elevation from the 'Reference Point' to Node#1 or from Node#1 to Node#2. (Elevation of any particular point will be displayed in Google Earth Pro at the bottom right corner, next to latitude and longitude).
12. <Connection> refers to the connection(s) of the specific ingress lane to egress lanes.
13. `<Lane Number>13</LaneNumber>` refers to the Lane Number of the egress lane with which, the ingress lane is connected.
14. `<Maneuver>1</Maneuver>` refers to type the type of maneuver involved.

Logic For Calculating Maneuver Value

Connected Lanes

The connected lane must be of the same type as the described lane. The maneuver code is a bit-mapped value as follows.

```
0 (LSB)                  Straight Ahead    4     Soft Left Turn
1  Left Turn             5    Soft Right Turn
2  Right Turn            6    Merge Left
3  U-Turn                7    Merge Right
```

Example-1:

Lane#3 in the sample is permitting a through maneuver, which means the binary value is 00000001. Converted decimal value would be 1.

Example-2:

A lane is providing left, through and right maneuvers, which makes the binary value to be 0000111. Converted decimal value would be 7.

15. `<SignalGroup>2</SignalGroup>` refers to the signal group that permits the specific maneuver.

INSTRUCTIONS FOR CREATING COMPUTED LANES USING VEHICLE LANES

1. Add all the lanes comprising varied lane length, shape and type as vehicle lanes.
2. To add the computed lanes, select the left most ingress vehicle lanes in the direction of travel as reference.
3. Measure the X-offset (distance in East (+) or West (-) direction) and Y-offset (distance in North (+) or South (-) direction) between the reference vehicle lane and the desired computed lane.
4. Always start from west most set of lanes, find the center line of that set of lanes (i.e., North most ingress lane in this case) as shown in Figure 6.

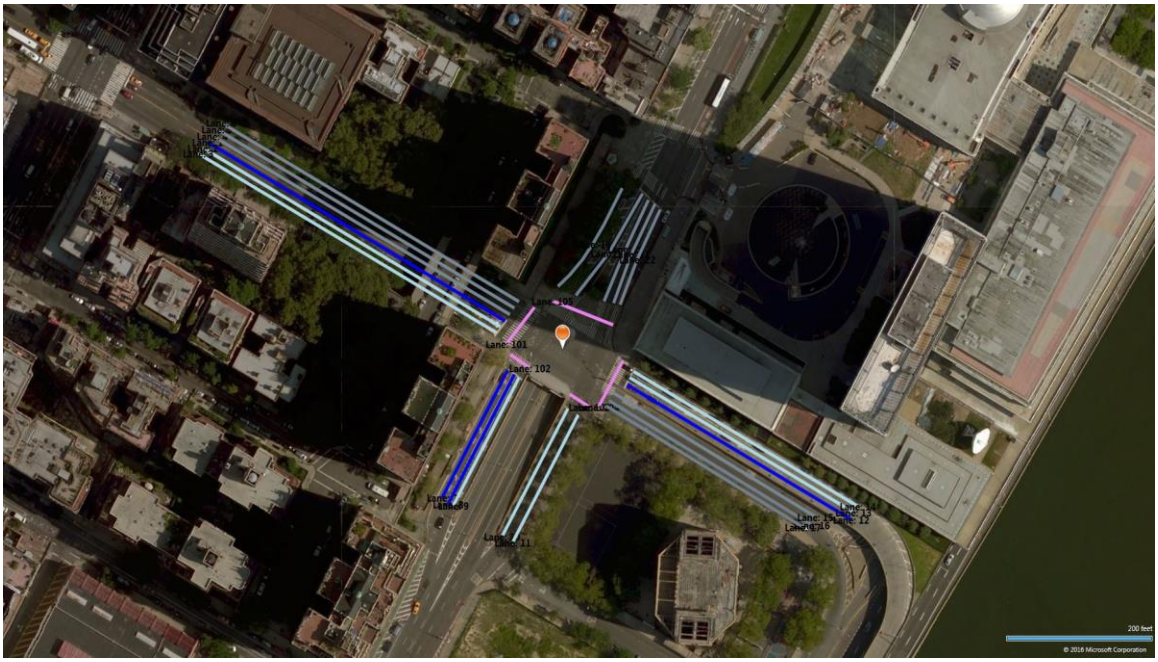

Figure 6. A Typical Intersection in Map Creator Application Displaying Ingress and Egress Lanes in Different Directions

5. Add all the ingress lanes in counter clockwise direction (going away) from center line (West ingress lanes 2 & 3 were drawn counter clockwise based on lane 1 in Figure 6).
6. Note that going away from the center line direction will change according to which lane group is being mapped. West lane group-> from center line going South, South lane group-> from center line going East, East lane group-> from center line going North, and North lane group-> from center line going West.
7. Now that all ingress lanes are mapped, add all the egress lanes in clockwise direction from center line. (West egress lanes 4, 5 & 6 were drawn clockwise based on lane 1 in Figure 6).
8. Repeat the same process in all directions.
9. In case of One-way egress lanes, left most egress lanes is mapped first and followed by the rest of the egress lanes in clockwise direction (North egress lanes 18, 19, 20, 21, and 22 in Figure 6 were drawn in clockwise direction).

SAMPLE .XML CODE FOR A COMPUTED LANE

The computed lanes can be added using ‘Add Computed Lane’ option in the Map Creator application.

```
</Lane>
<Lane Number="2">
<Type>Computed</Type>
<Attributes>2</Attributes>
<Width>200</Width>
<Nodes />
<Connection>
<LaneNumber>14</LaneNumber>
<Maneuver>1</Maneuver>
<SignalGroup>2</SignalGroup>
</Connection>
<Connection>
<LaneNumber>15</LaneNumber>
<Maneuver>1</Maneuver>
```

```
<SignalGroup>2</SignalGroup>
</Connection>
<Connections />
<ReferenceLane>
<LaneNumber>1</LaneNumber>
<YOffset>-19</YOffset>
<XOffset>-29</XOffset>
<ZOffset>-3</ZOffset>
</ReferenceLane>
```

The specific changes in the code will be the lane type (computed) and Reference lane characteristics.

1. `<LaneNumber>1</LaneNumber>` refers to the vehicle lane that is taken as a reference for computing this 'Computed lane'.
2. `<YOffset>-19</YOffset>` refers to the distance of 'Computed lane' from 'Reference vehicle lane' in North (+) or South (-) direction.
3. `<XOffset>-29</XOffset>` refers to the distance of 'Computed lane' from 'Reference vehicle lane' in East (+) or West (-) direction.
4. `<ZOffset>-3</ZOffset>` refers to the difference in elevation from 'Vehicle Lane' to the 'Computed Lane'.

SPECIAL CASE – PARKING LANE

The criteria below helps to set the binary attribute logic for parking lanes. The rest of the procedure remains the same, as in the case of vehicle lanes, except for the connections. None of the parking lanes will have a connection, as it is strictly intended for parking.

```
0 (LSB)   Parking Revocable Lane -- this lane may be activated or not
          based on the current SPAT message contents. If not asserted, the
          lane is ALWAYS present
1         Parallel Parking In Use
2         Head In Parking In Use
3         Do Not Park Zone -- used to denote fire hydrants as well as
          short disruptions in a parking zone
4         Parking for Bus Use
5         Parking for Taxi Use
6         No Public Parking Use  -- Private parking, as in front of
          private property
7-15      Reserved
```