

RWR 4013

# Digital Twins for Smart Cities

Dr. Ahmad Mohammadi

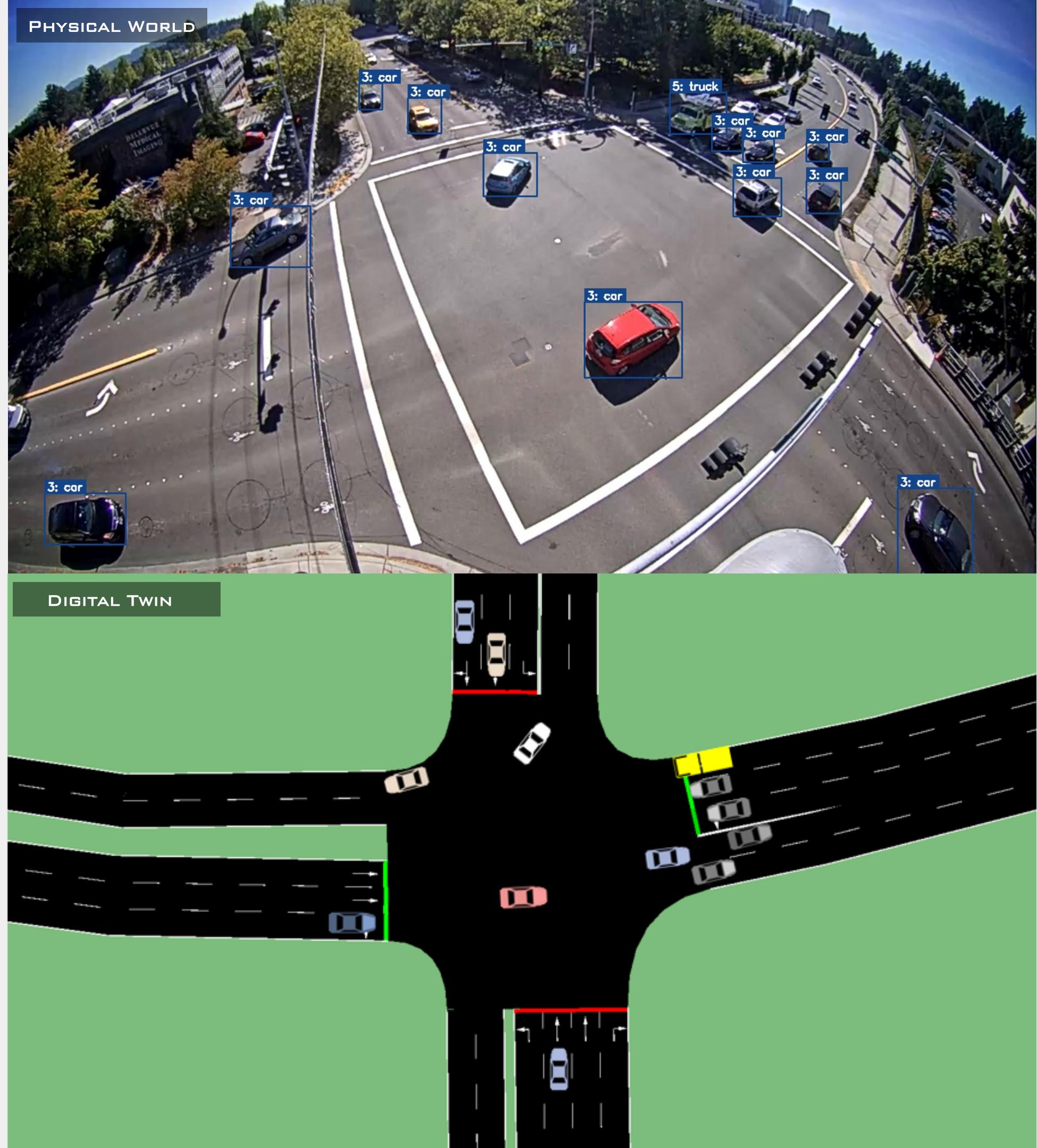
Week 6 | Session 2:  
Lane Connections, Right of Way,  
Traffic Signal

Fall 2026

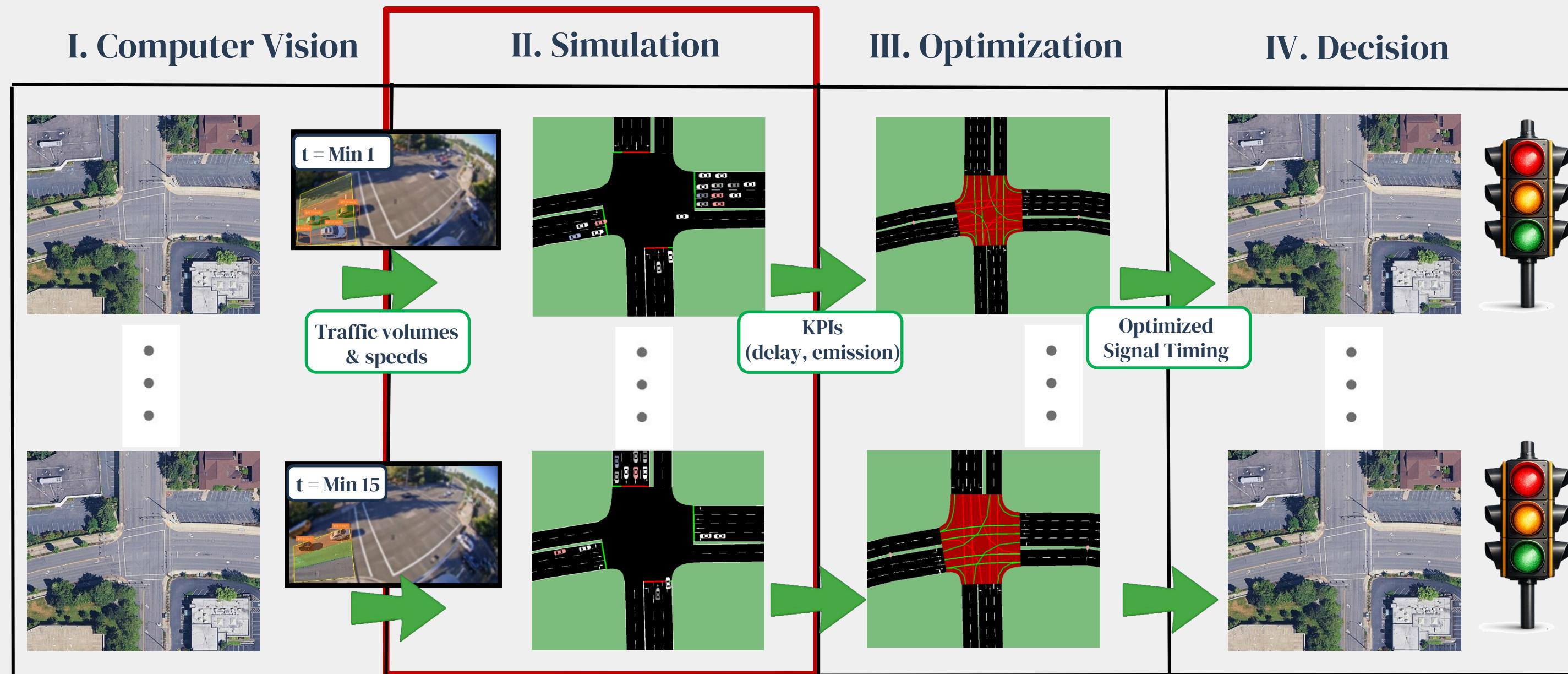
RoadwayVR



[roadwayvr.github.io/DigitalTwinsforSmartCities](https://roadwayvr.github.io/DigitalTwinsforSmartCities)

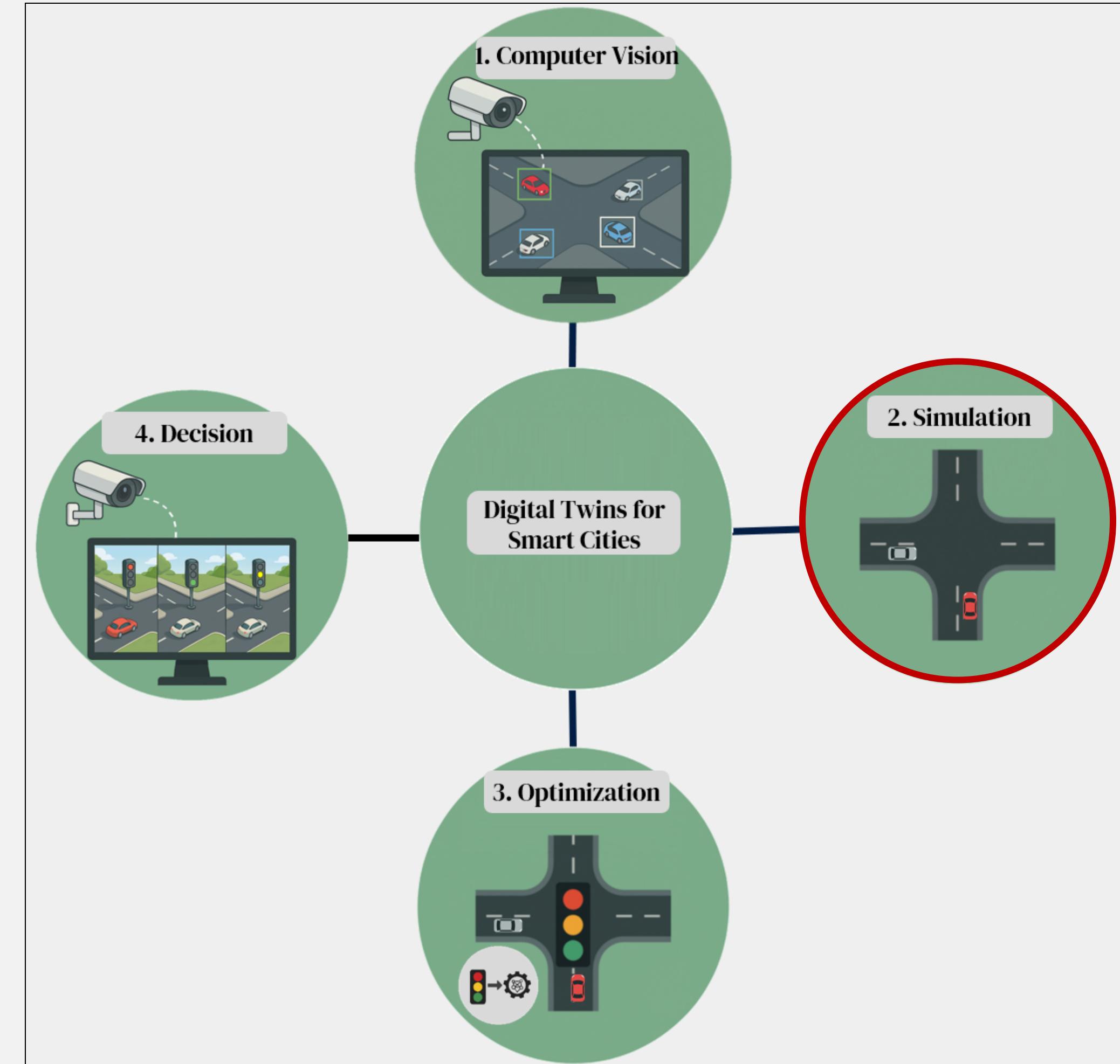


# Overview of Course Syllabus in One Shot



# Agenda

- ❑ Lane Connections
- ❑ Right of Way
- ❑ Traffic Signal
- ❑ Traffic Flows (Demand)



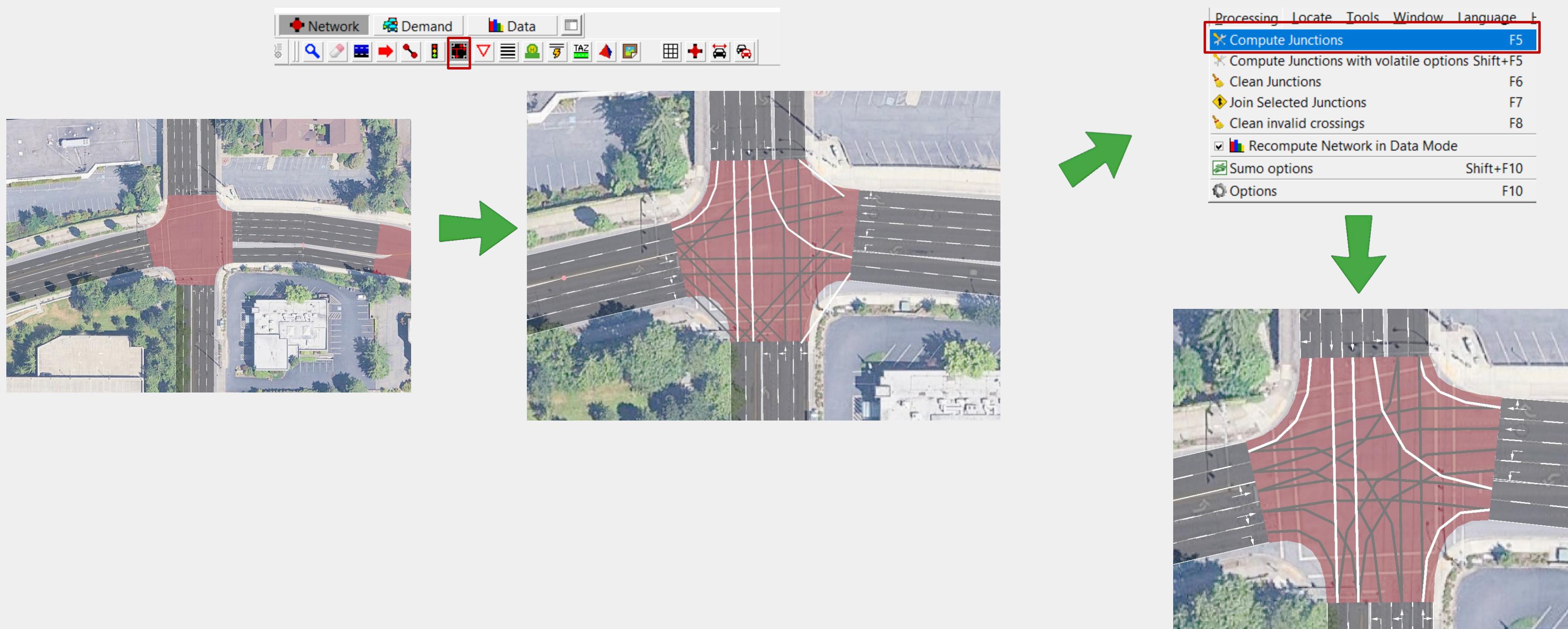
# Download Materials

1. Download Week6b.Material.zip and extract it
2. Open Exercise2.netecfg
3. Assign the Background Map
4. Adjust transparency to roads and junctions



# Download Materials

- Select “Connection” tool

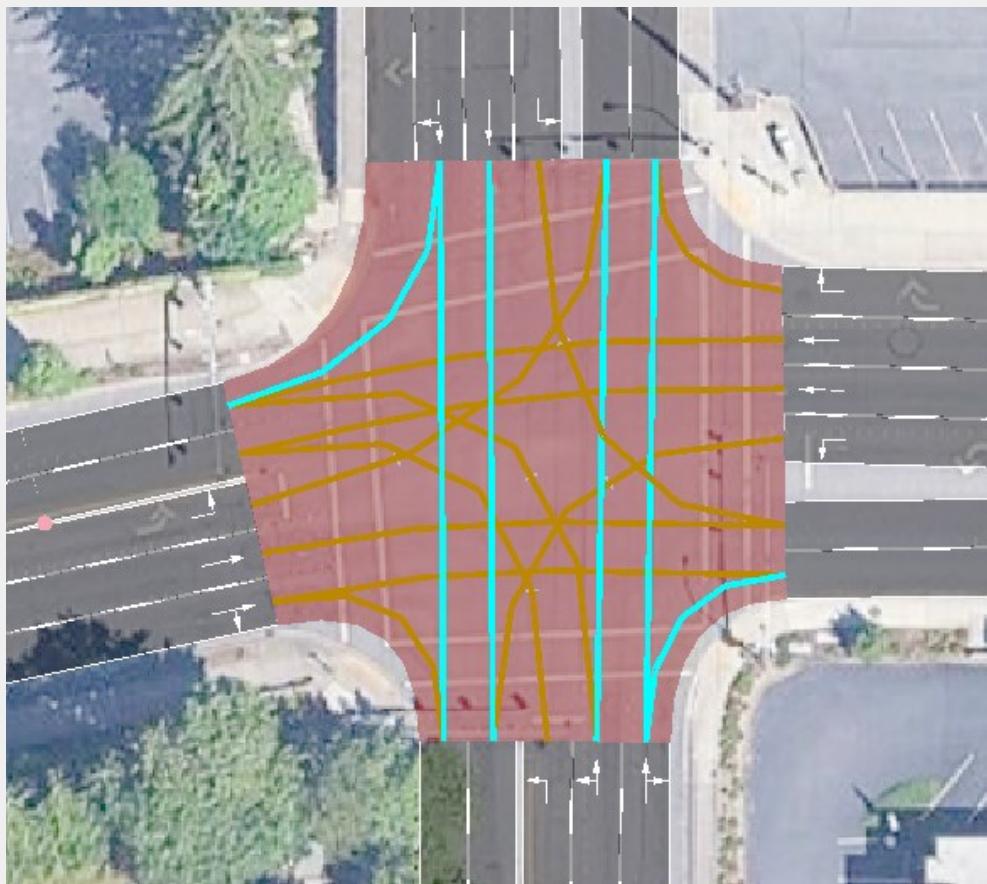
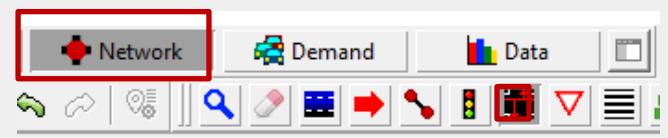


# Lane Connections, Right of Way, Traffic Signal

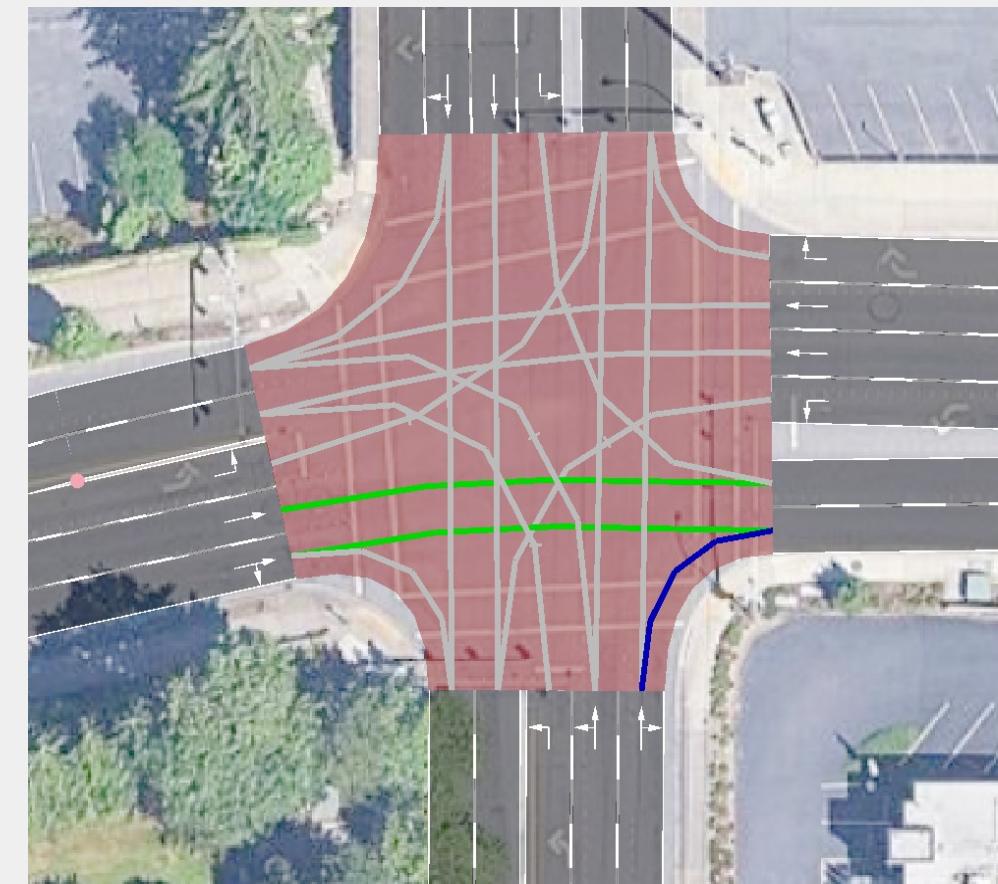
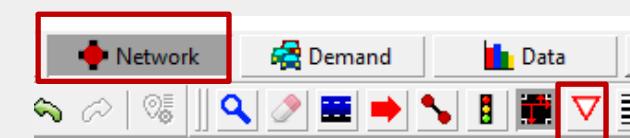
## Elements of Junction

---

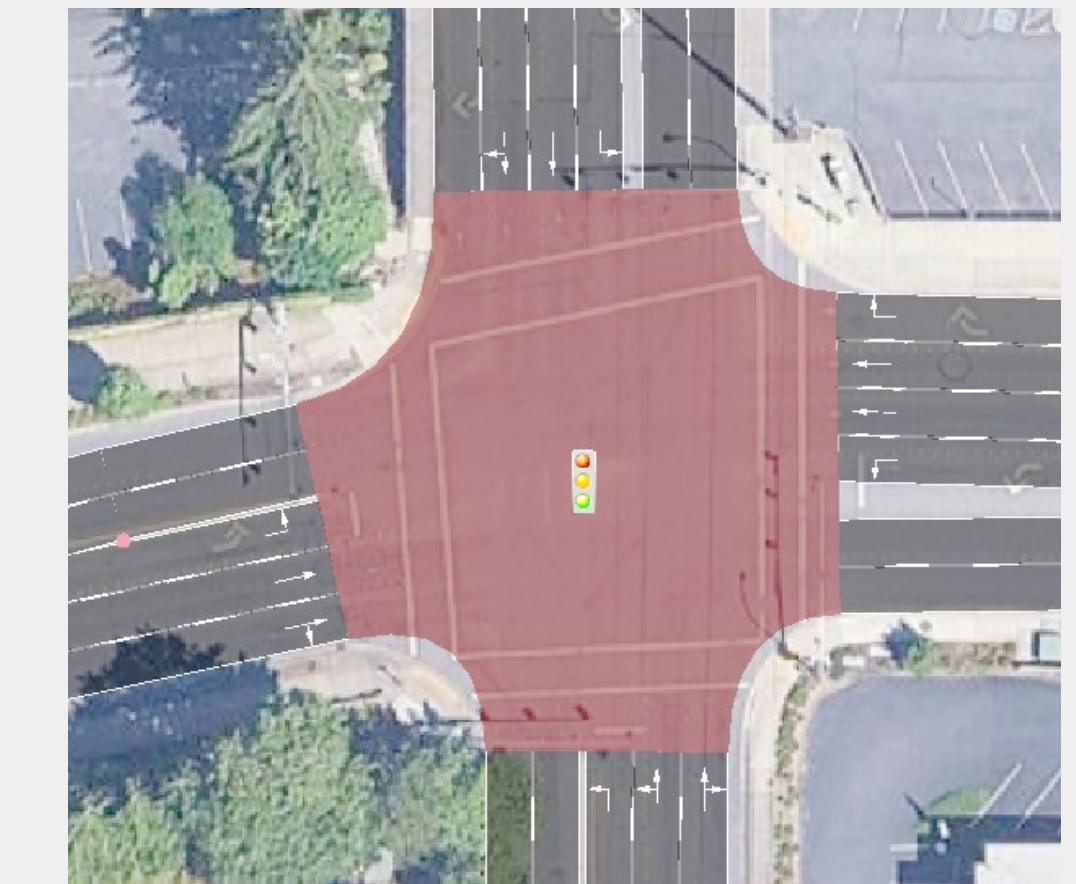
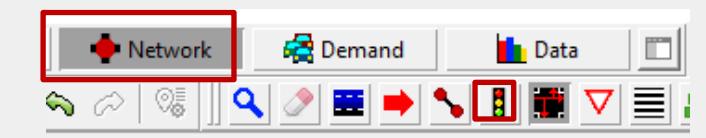
Connections



Right of Way



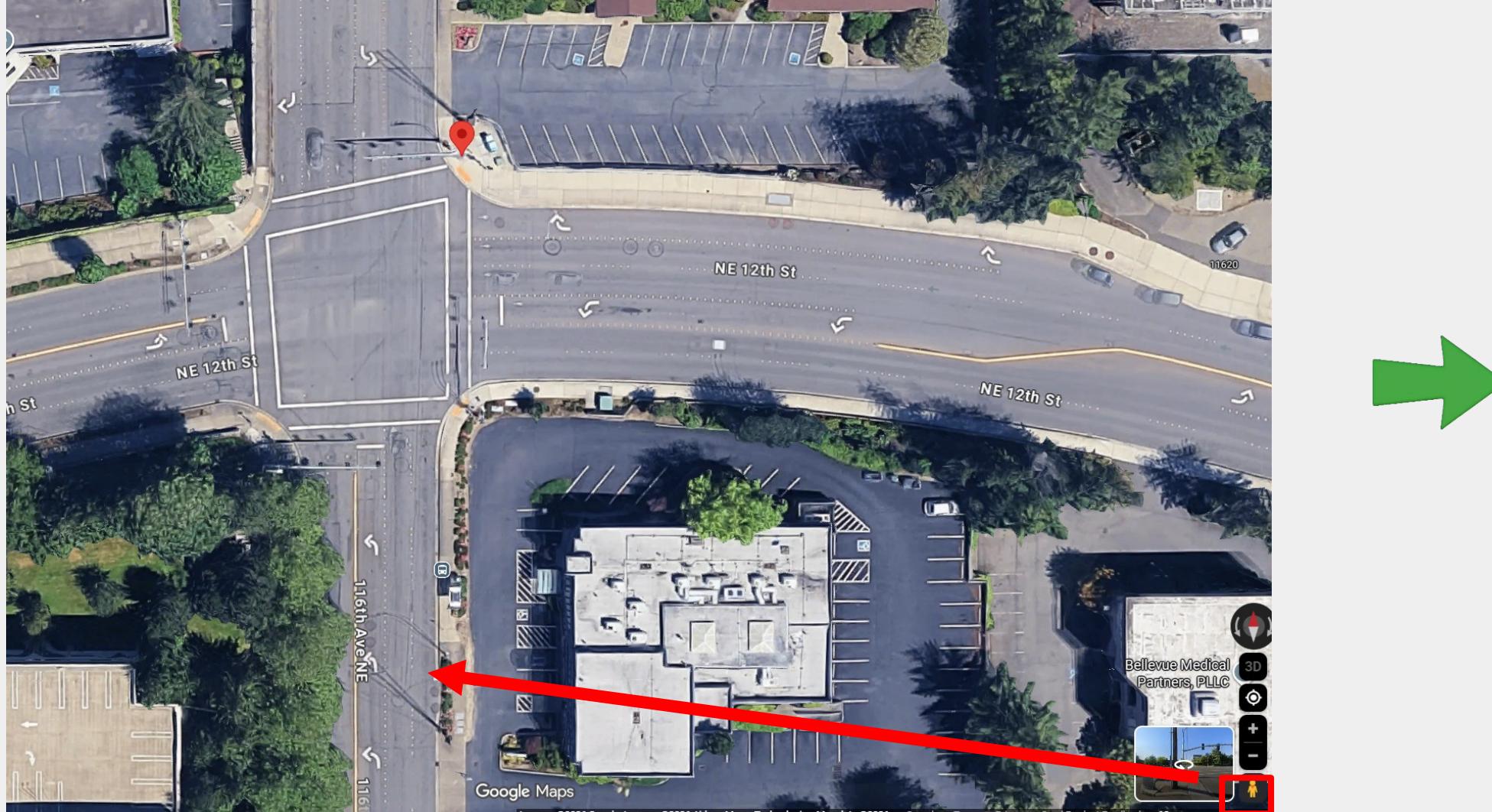
Traffic Signal



# Lane Connections - Verify in Google Maps

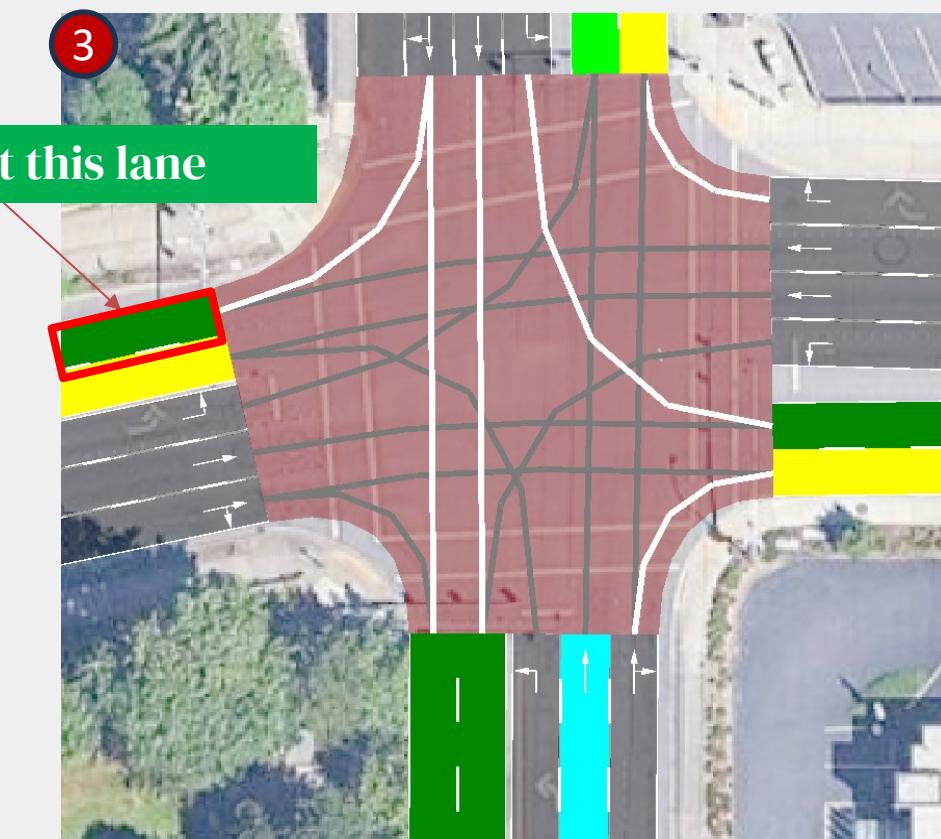
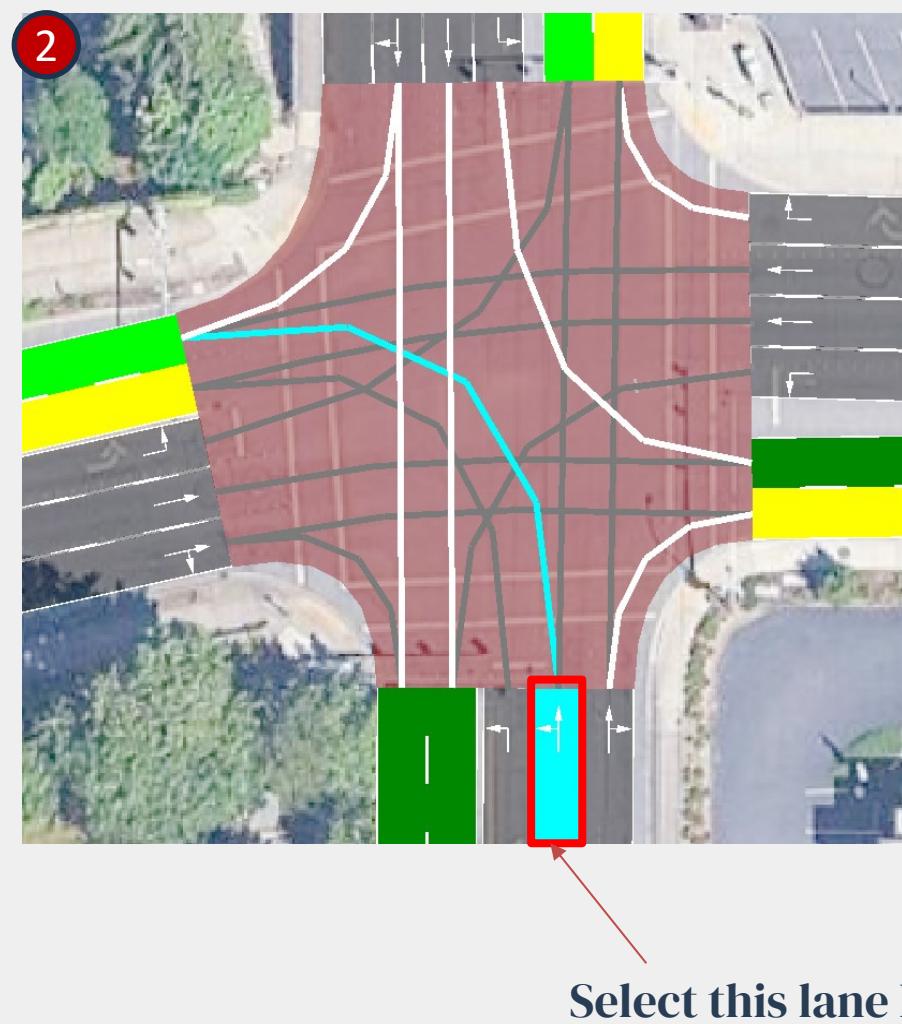
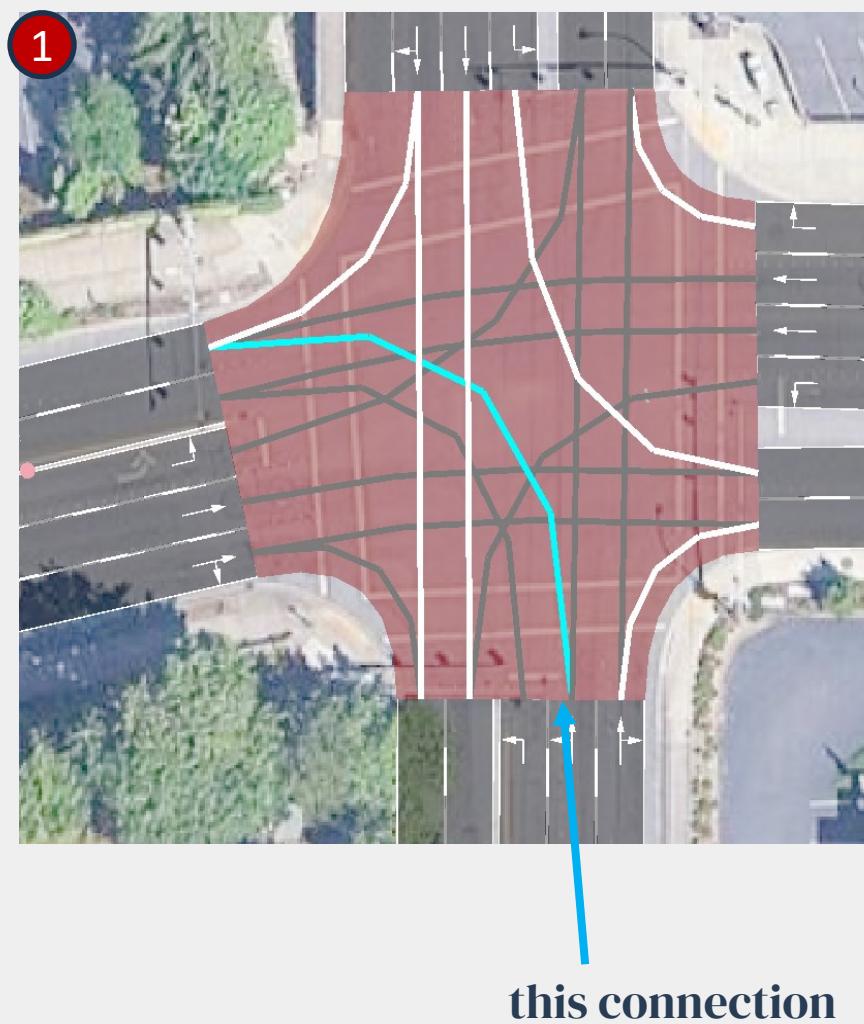
Search the study area location on the map.

- Coordinates: 47.62293830628107, -122.18554859584597
- Open Street View.
- Drag and drop the Pegman onto the northbound approach and visually verify which link corresponds to which road segment / movement.



# Lane Connections

- Select the northbound through movement.
- This lane is through-only and does not include a left turn (See Streetview).
- Remove this connection



**Edit Connections**

Lane  
Current Lane: E17\_1

Modifications  
Cancel  OK  
 Protect routes

Operations  
Select Dead Ends  
Select Dead Starts  
Select Conflicts  
Select Passing  
Clear Selected  
Reset Selected

Selection  
- Hold <SHIFT> while clicking to create unyielding connections (pass=true).  
- Hold <CTRL> while clicking to create conflicting connections (i.e. at zipper nodes or with incompatible permissions)

Information

# Lane Connections

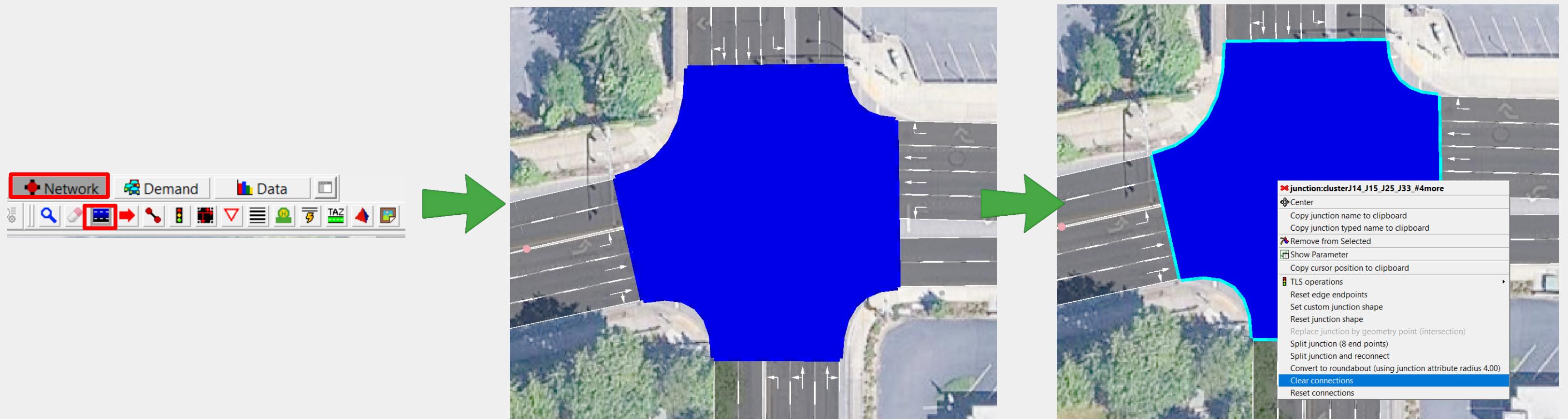
- The extra connection has been removed.



- Check the remaining connections.

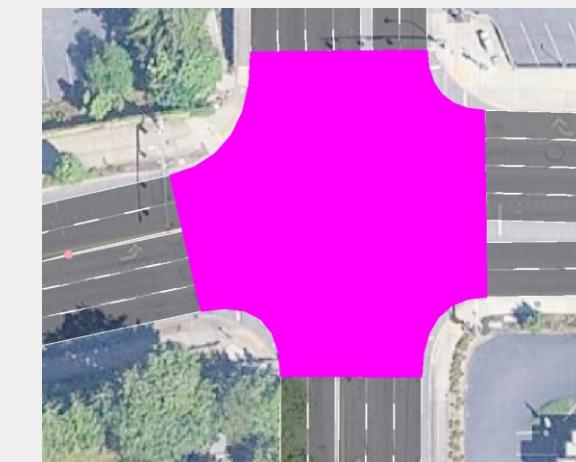
# Lane Connections

- Now, let's remove all connections and recreate them manually.



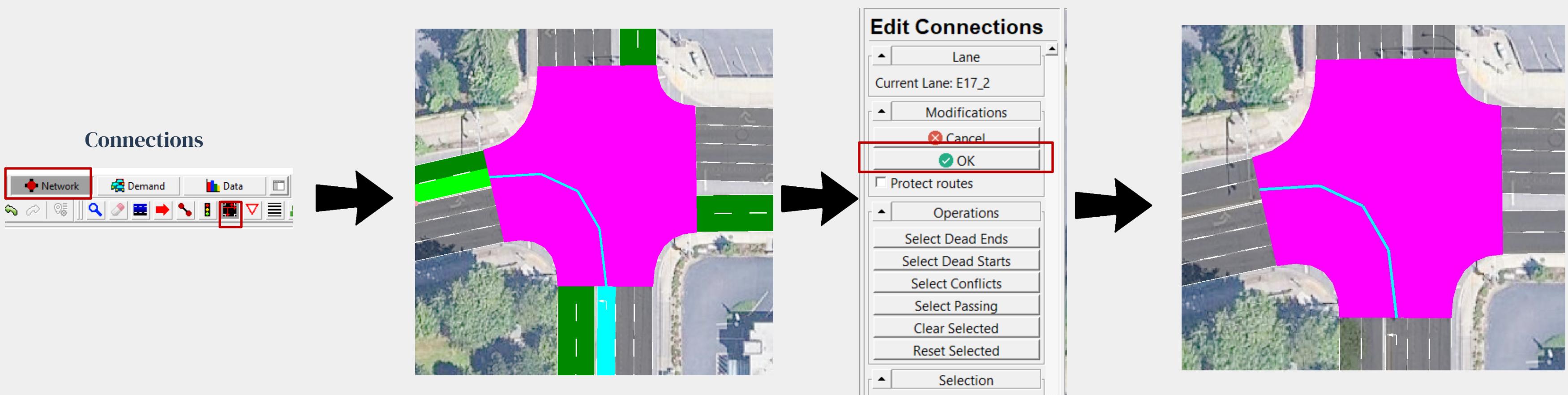
- Notice that there are no connections.

Press Esc to deselect, or click again to reselect.



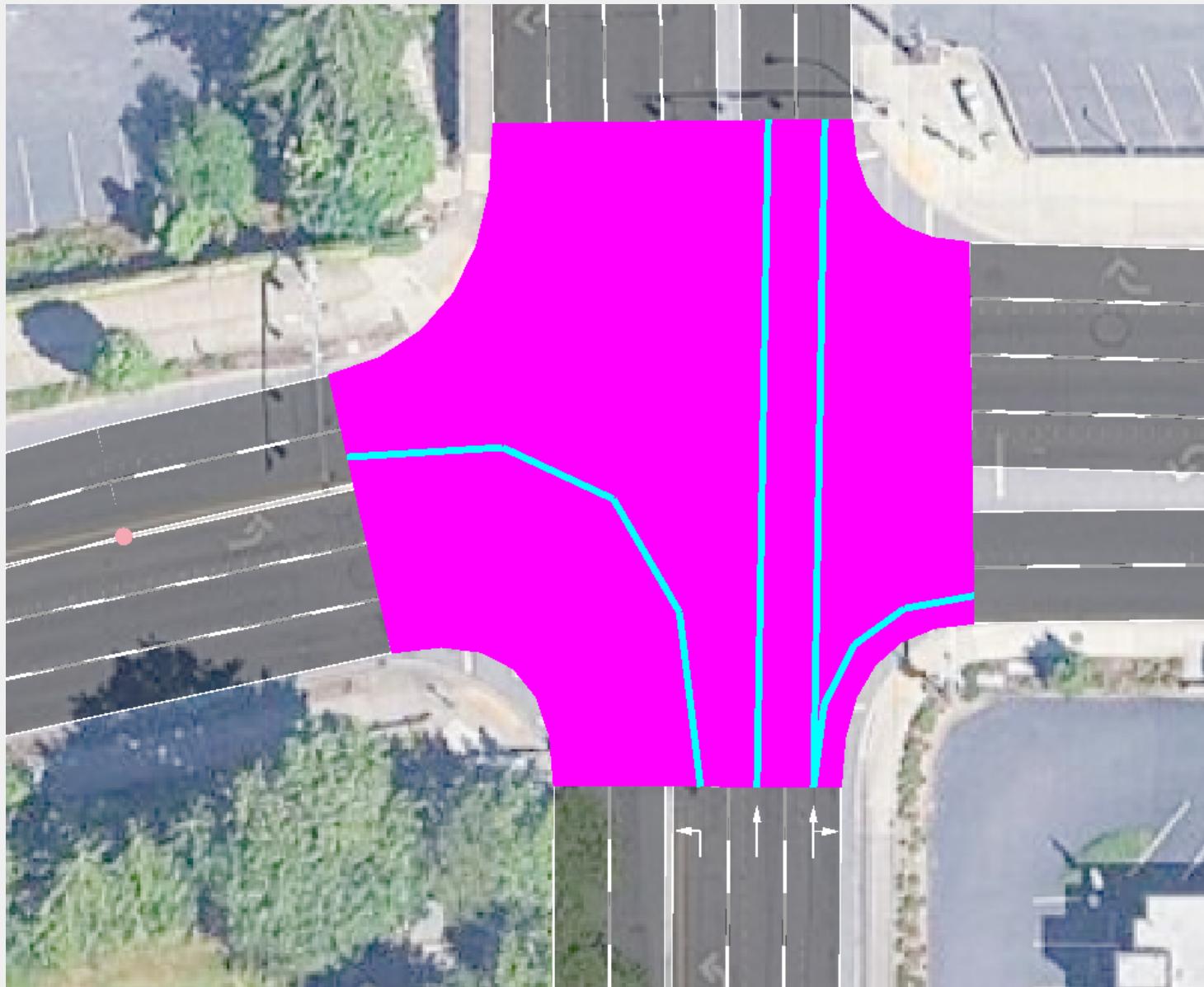
# Lane Connections

- ❑ Use Street View to identify the correct lane connections.
- ❑ Then connect the northbound links accordingly.



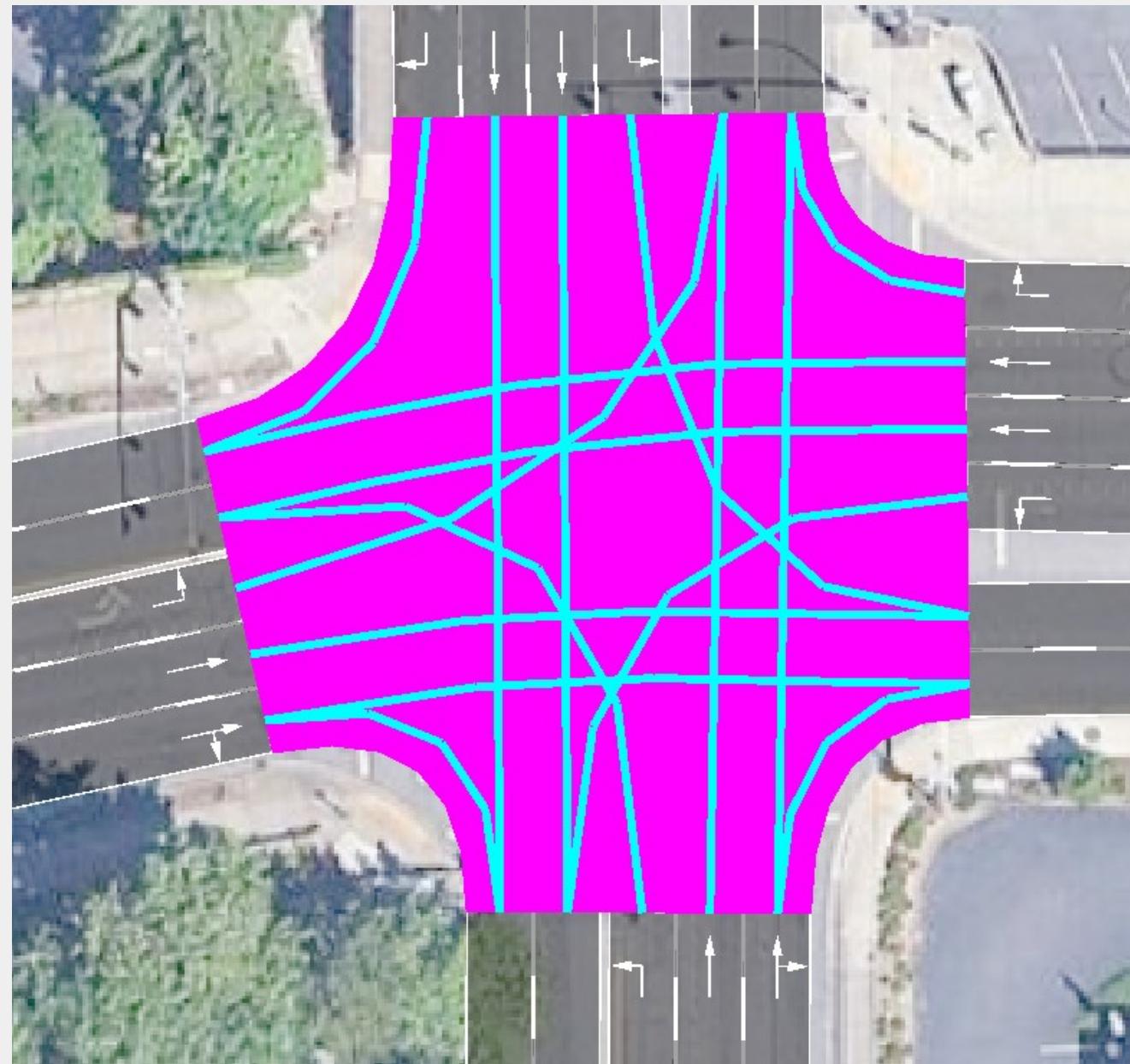
# Lane Connections

- ❑ Northbound lane connections: final result
- ❑ Verify using street view to confirm accuracy



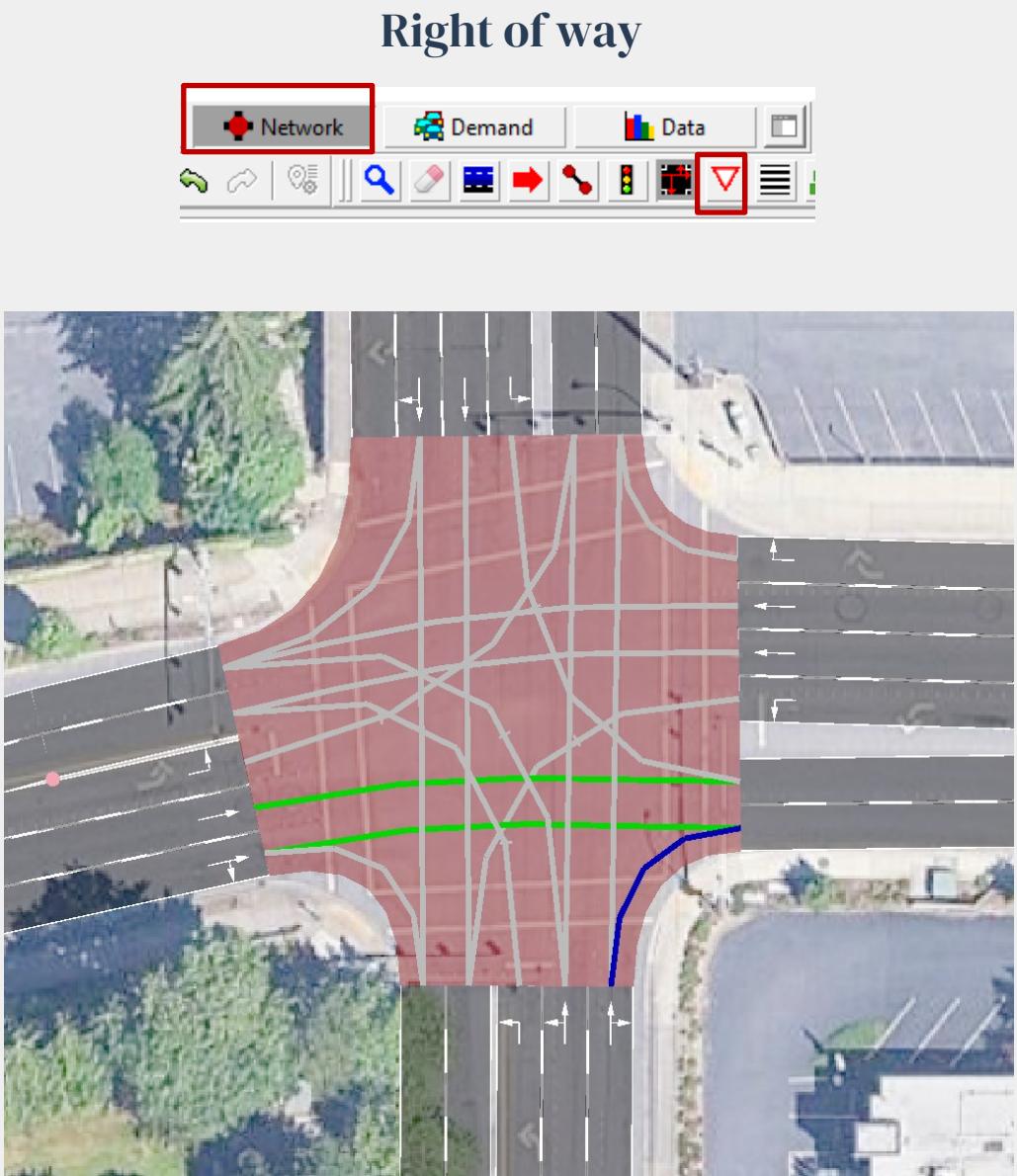
# Lane Connections

- Repeat the same process for the remaining lanes.



# Right of Way

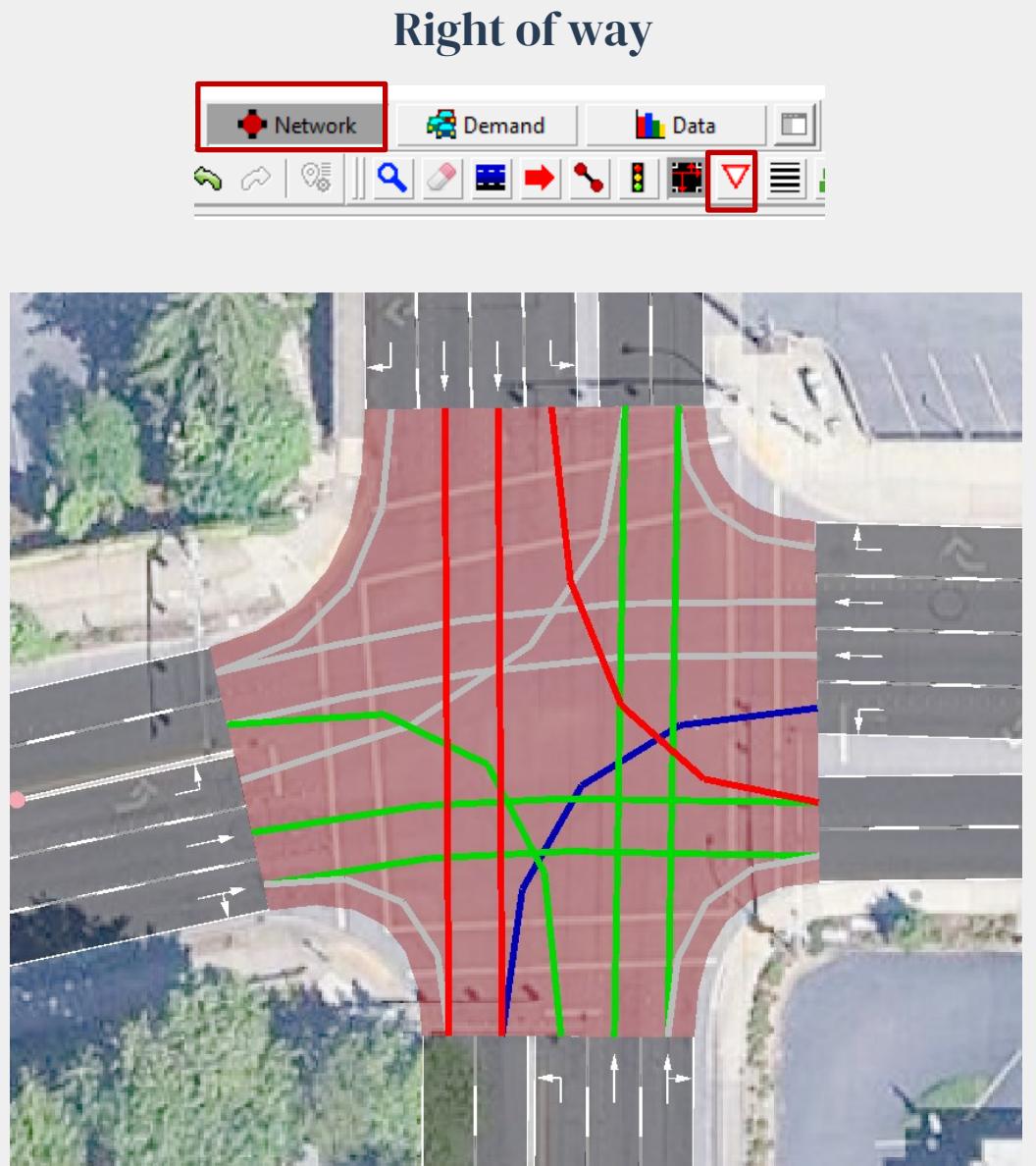
- Select Network → Select “Prohibitions” tool
- Select the northbound rightmost lane.



- The Traffic on the blue Connection **Yields** to traffic on the **green connection**

# Right of Way

- Select the westbound leftmost lane.



- Traffic on the **blue connection yields** to traffic on the **green connection**
- Traffic on the **blue connection has right of way over** to the **red connection**

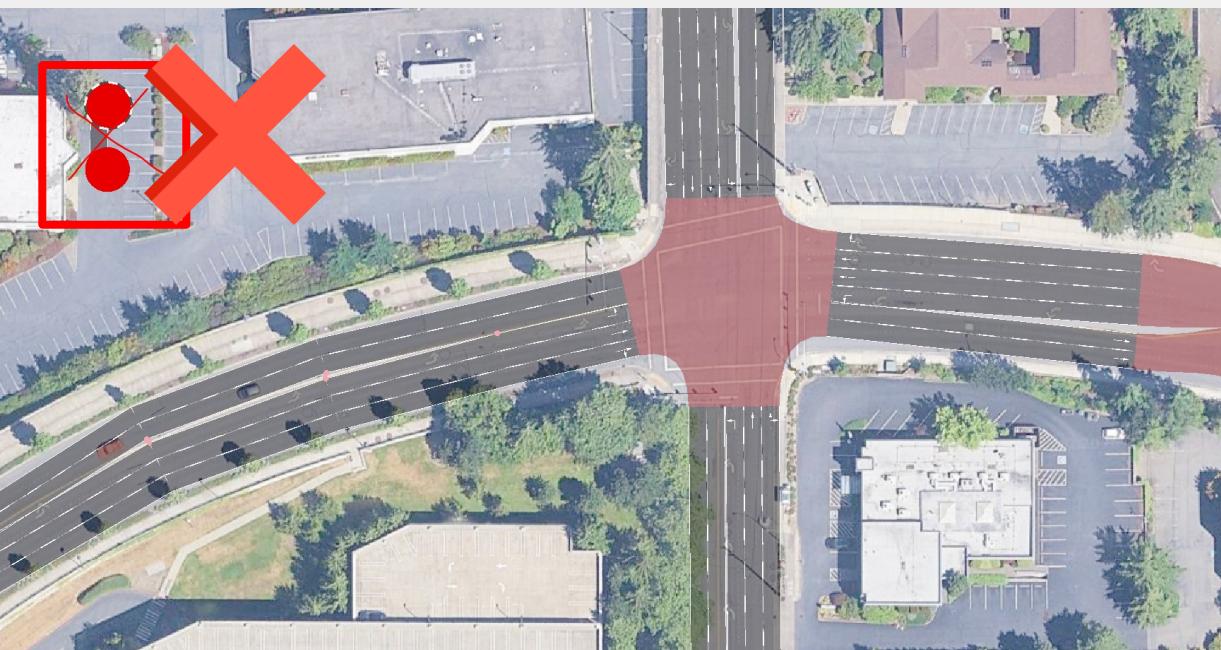
# Traffic Signal

- Select Junction
- Make sure the name is “J1”



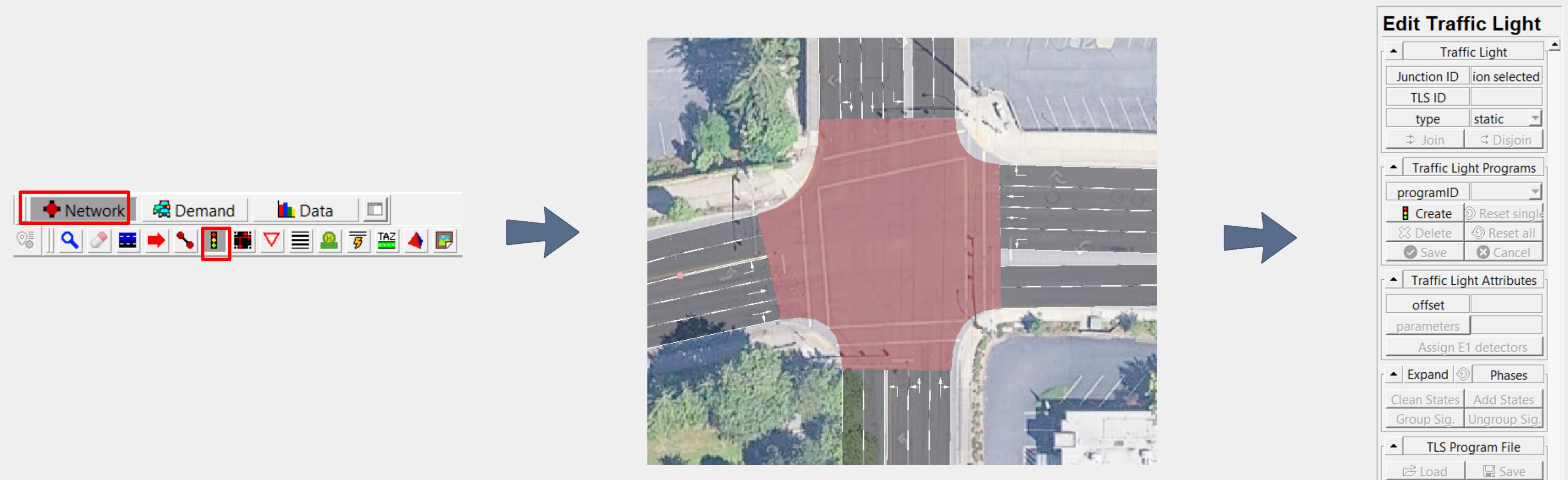
Net: junction	
Internal attributes	
id	J1
pos	-16.02,60.58
type	affic_light
shape	4 -1.38,73.63
radius	default
keepClear	<input checked="" type="checkbox"/> true
rightOfWay	default
fringe	default
name	
tlType	static
tlLayout	default
tl	J33_#4more
isRoundabout	<input type="checkbox"/> false

- If you get an error because J1 already exists, remove the dummy junctions/roads using the Eraser tool.



# Traffic Signal

## □ Select Traffic Signal



# Traffic Signal

**Edit Traffic Light**

**Traffic Light**

Junction ID	J33_#4more
TLS ID	J33_#4more
type	static
<input type="button" value="Join"/> <input type="button" value="Disjoin"/>	

**Traffic Light Programs**

programID	0
<input type="button" value="Duplicate"/>	<input type="button" value="Reset single"/>
<input type="button" value="Delete"/>	<input type="button" value="Reset all"/>
<input checked="" type="checkbox"/> Save	<input type="button" value="Cancel"/>

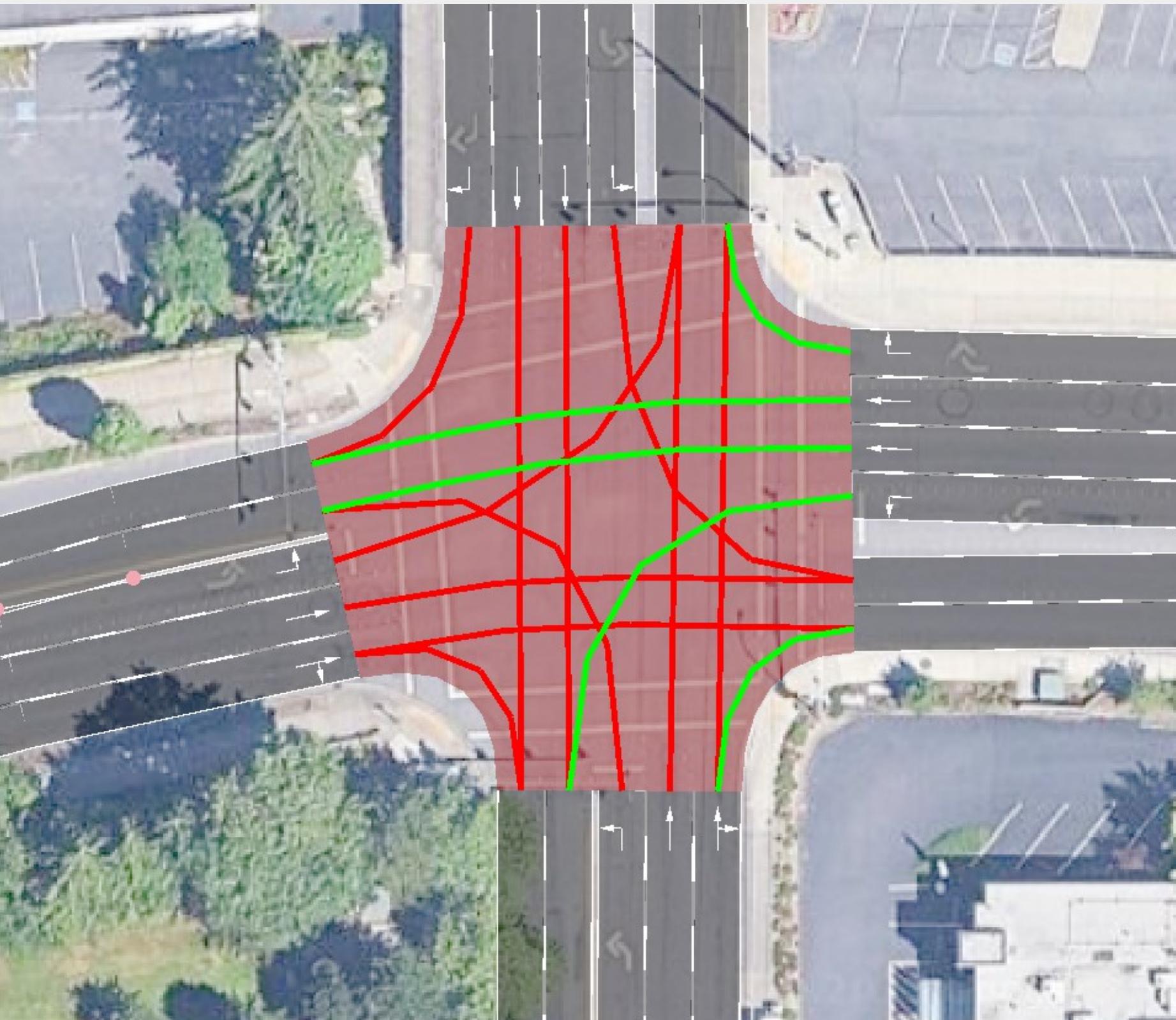
**Traffic Light Attributes**

offset	0.00
parameters	
<input type="button" value="Assign E1 detectors"/>	

**Expand**

	dur	state
0	17.00	GGGGGrrrrrrr
1	3.00	Gyyyyrrrrrrr
2	20.00	Grrrrrrrrrrrr
3	3.00	yrrrrrrrrrrrr
4	20.00	rrrrrrrrrGGG
5	3.00	rrrrrrrrrGyy
6	20.00	rrrrrGGGGGrr
7	3.00	rrrrryyyyyyrr
8	1.00	rrrrrrrrrrrr
$\Sigma$	90.00	Links: 16

**TLS Program File**



# Traffic Signal

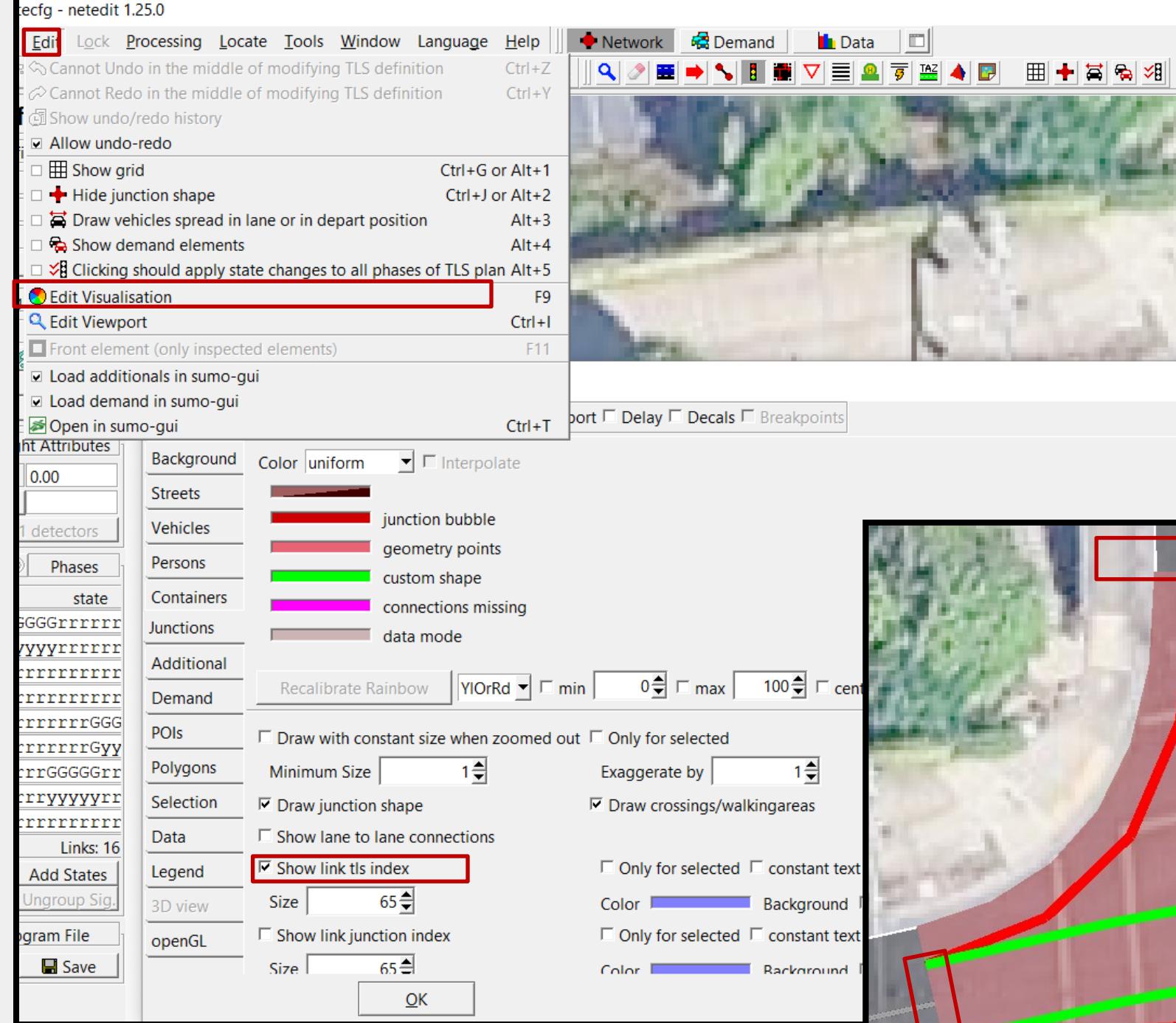
5. Select Traffic Light

6. Edit → Edit Visualization

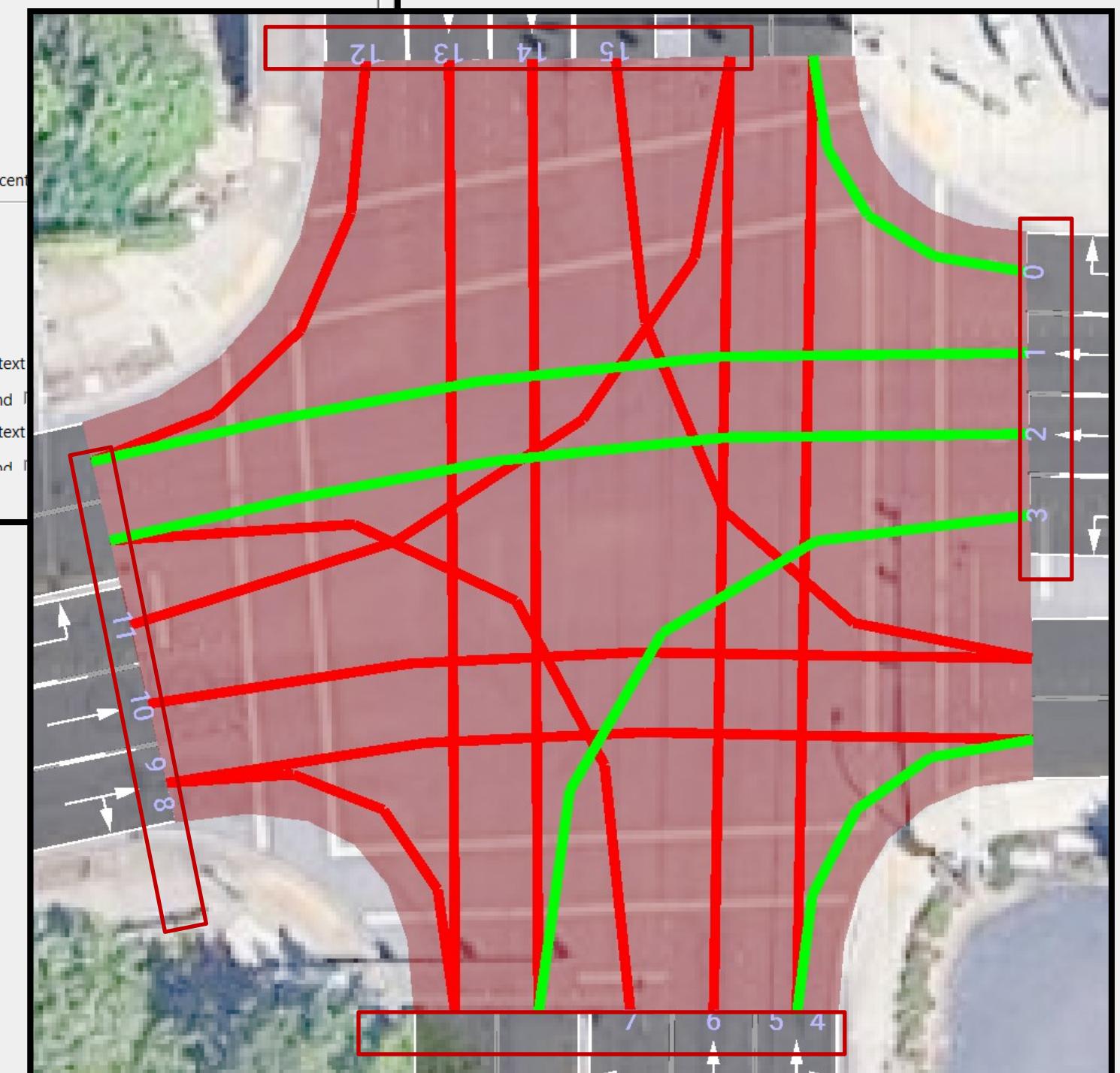
7. Select Traffic Light

8. Select Junction

9. Show link tls index



10. See each traffic signal head number



# Traffic Signal

10. Review the phase table (left panel) in the “Edit Traffic Light” window:

- Phase 0: 17 s
- Phase 1: 3 s
- Phase 2: 20 s
- Phase 3: 3 s
- Phase 4: 20 s
- Phase 5: 3 s
- Phase 6: 20 s
- Phase 7: 3 s
- Phase 8: 1 s

11. State:

G = Green

y = means Yellow

r = means Red

In phase 0:

GGGGGrrrrrrrrrrrr



In phase 1:

Gyyyrrrrrrrrrrrrr



**Edit Traffic Light**

Traffic Light

Junction ID: JsterJ14\_J15\_J25\_J33\_#4more  
TLS ID: JsterJ14\_J15\_J25\_J33\_#4more  
type: static

Join Disjoin

Traffic Light Programs

programID: 0

Duplicate Reset single  
Delete Reset all  
Save Cancel

Traffic Light Attributes

offset: 0.00  
parameters

Assign E1 detectors

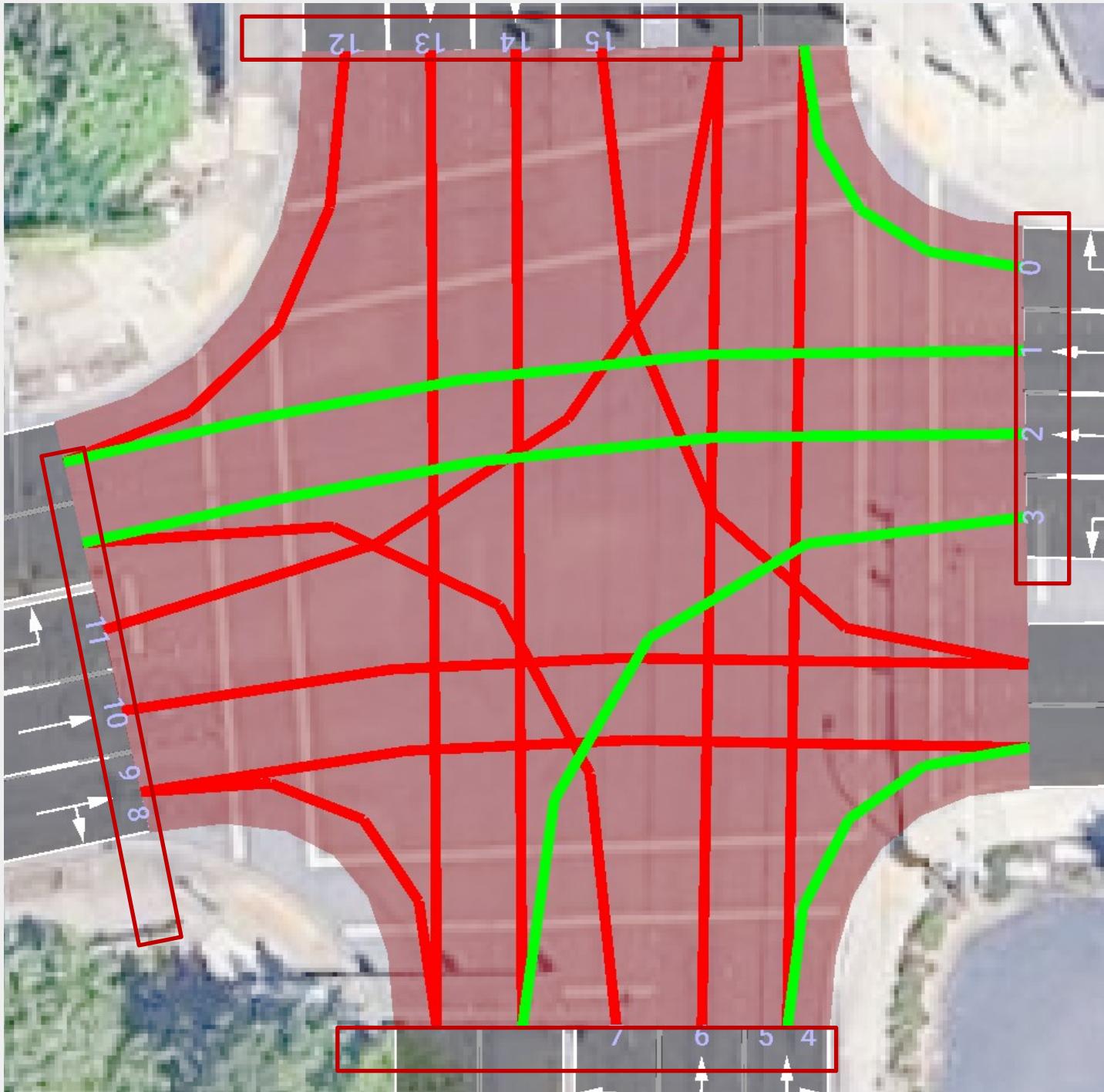
Phases

	dur	state	next
0	17.00	GGGGGrrrrrrrrrrrr	
1	3.00	Gyyyyrrrrrrrrrrrr	
2	20.00	Grrrrrrrrrrrrrrrrrr	
3	3.00	yrrrrrrrrrrrrrrrr	
4	20.00	rrrrrrrrrrGGGGGrrrr	
5	3.00	rrrrrrrrrrGyyyyrrrr	
6	20.00	rrrrGGGGGrrrrrrrrrr	
7	3.00	rrrrryyyyyrrrrrrrrrr	
8	1.00	rrrrrrrrrrrrrrrrrrrr	
$\Sigma$	90.00	Links: 16	

Clean States Add States  
Group Sig. Ungroup Sig.

TLS Program File

Load Save



# Traffic Signal

10. Keep only four phases (Phases 0–3) →

**Edit Traffic Light**

Traffic Light

Junction ID	clusterJ14_J15_J25_J33_#4more
TLS ID	clusterJ14_J15_J25_J33_#4more
type	static

Join Disjoin

Traffic Light Programs

programID	0
-----------	---

Duplicate Reset single  
Delete Reset all  
Save Cancel

Traffic Light Attributes

offset	0.00
parameters	

Assign E1 detectors

Phases

	dur	state	next	name		
0	17.00	GGGGGrrrrrrrrrr				
1	3.00	Gyyyyrrrrrrrrrr				
2	20.00	GrrrrrrrrrrrrGGGG				
3	3.00	yrrrrrrrrrrrGyyy				
4	20.00	rrrrrrrrrGGGGGrrr				
5	3.00	rrrrrrrrrGyyyyrrr				
6	20.00	rrrrGGGGGrrrrrrr				
7	3.00	rrrryyyyyrrrrrrr				
8	1.00	rrrrrrrrrrrrrrrr				
Σ	90.00	Links: 16				



11. Delete Phases 4–8 using the red X

**Edit Traffic Light**

Traffic Light

Junction ID	clusterJ14_J15_J25_J33_#4more
TLS ID	
type	static

Join Disjoin

Traffic Light Programs

programID	0
-----------	---

Duplicate Reset single  
Delete Reset all  
Save Cancel

Traffic Light Attributes

offset	0.00
parameters	

Assign E1 detectors

Phases

	dur	state	next	name		
0	17.00	GGGGGrrrrrrrrrr				
1	3.00	Gyyyyrrrrrrrrrr				
2	20.00	GrrrrrrrrrrrrGGGG				
3	3.00	yrrrrrrrrrrrGyyy				
Σ	43.00	Links: 16				

Clean States Add States  
Group Sig. Ungroup Sig.

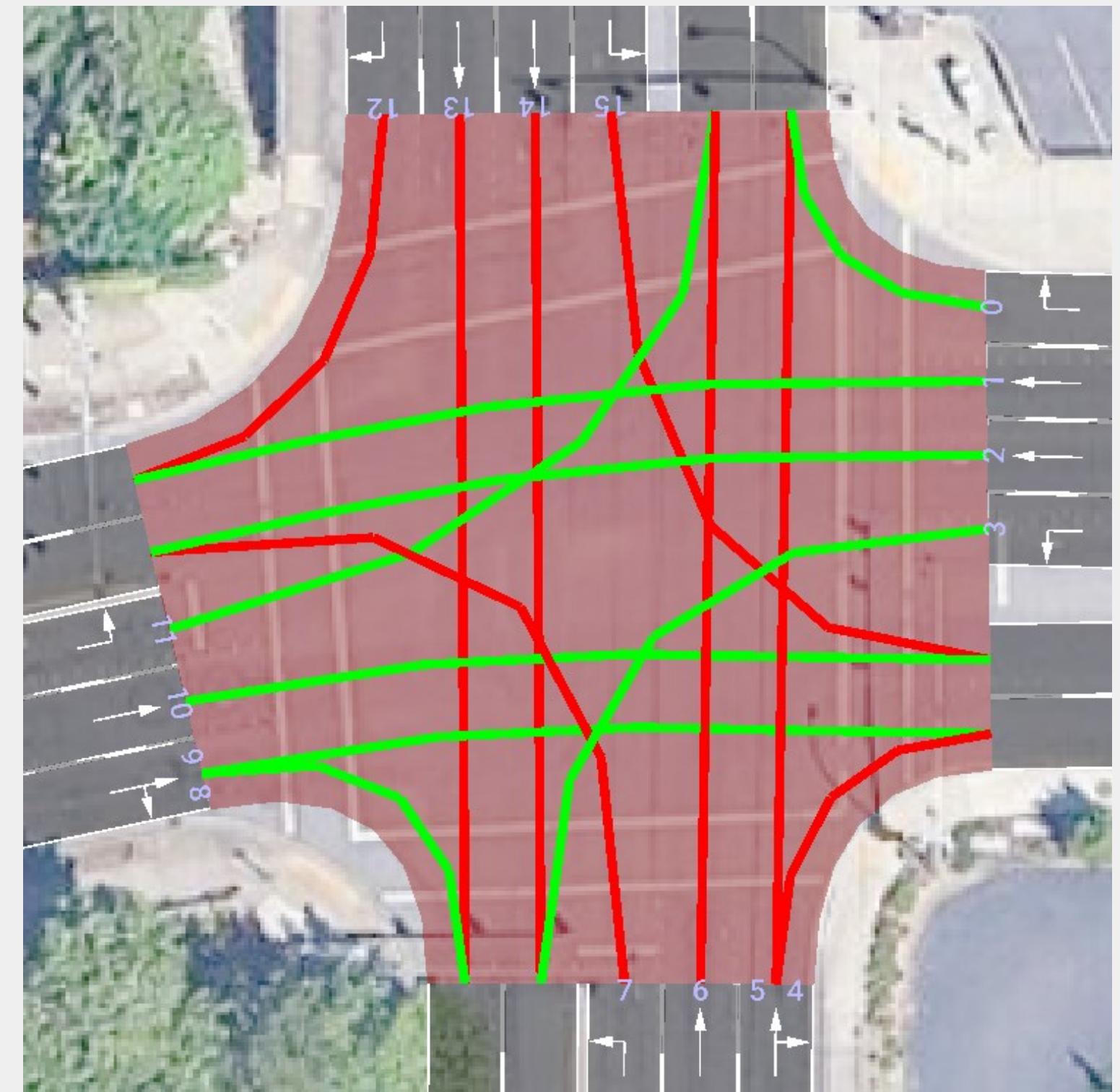
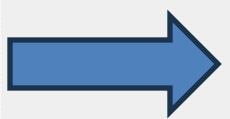
TLS Program File

Load Save

# Traffic Signal

## 12. Set the signal phases as follows:

## Phase 0: Eastbound + Westbound movements - Green



# Traffic Signal

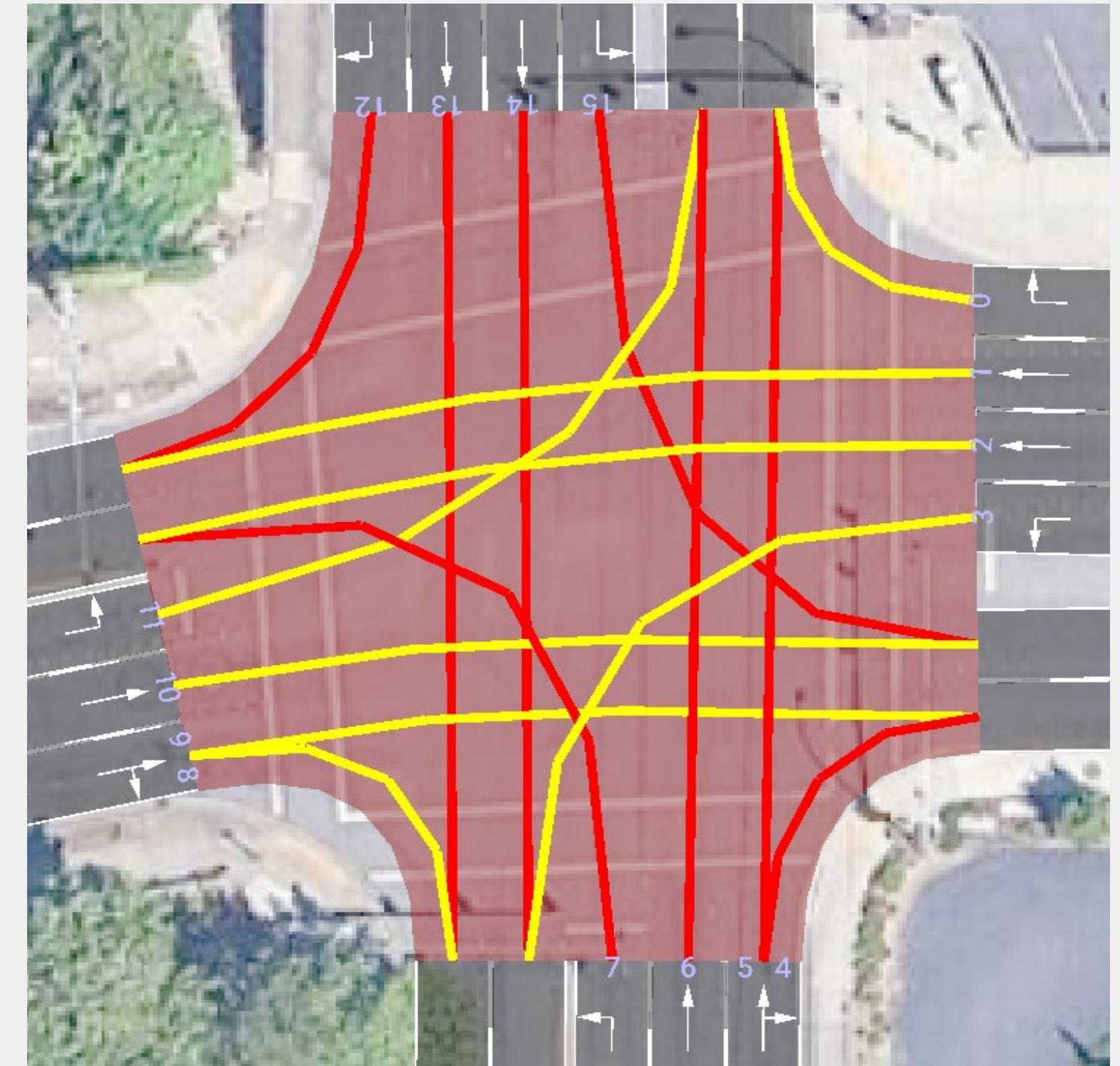
12. Set the signal phases as follows:

Phase 0: Eastbound + Westbound movements - Green

Phase 1: Eastbound + Westbound movements - Yellow (clearance)

► Expand ⟲

Phases			
	dur	state	next
0	27	GGGGGrrrrrGGGGGrrrrr	I
1	3.00	yyyyyrrrrryyyyyrrrr	
2			
3			
Σ			



# Traffic Signal

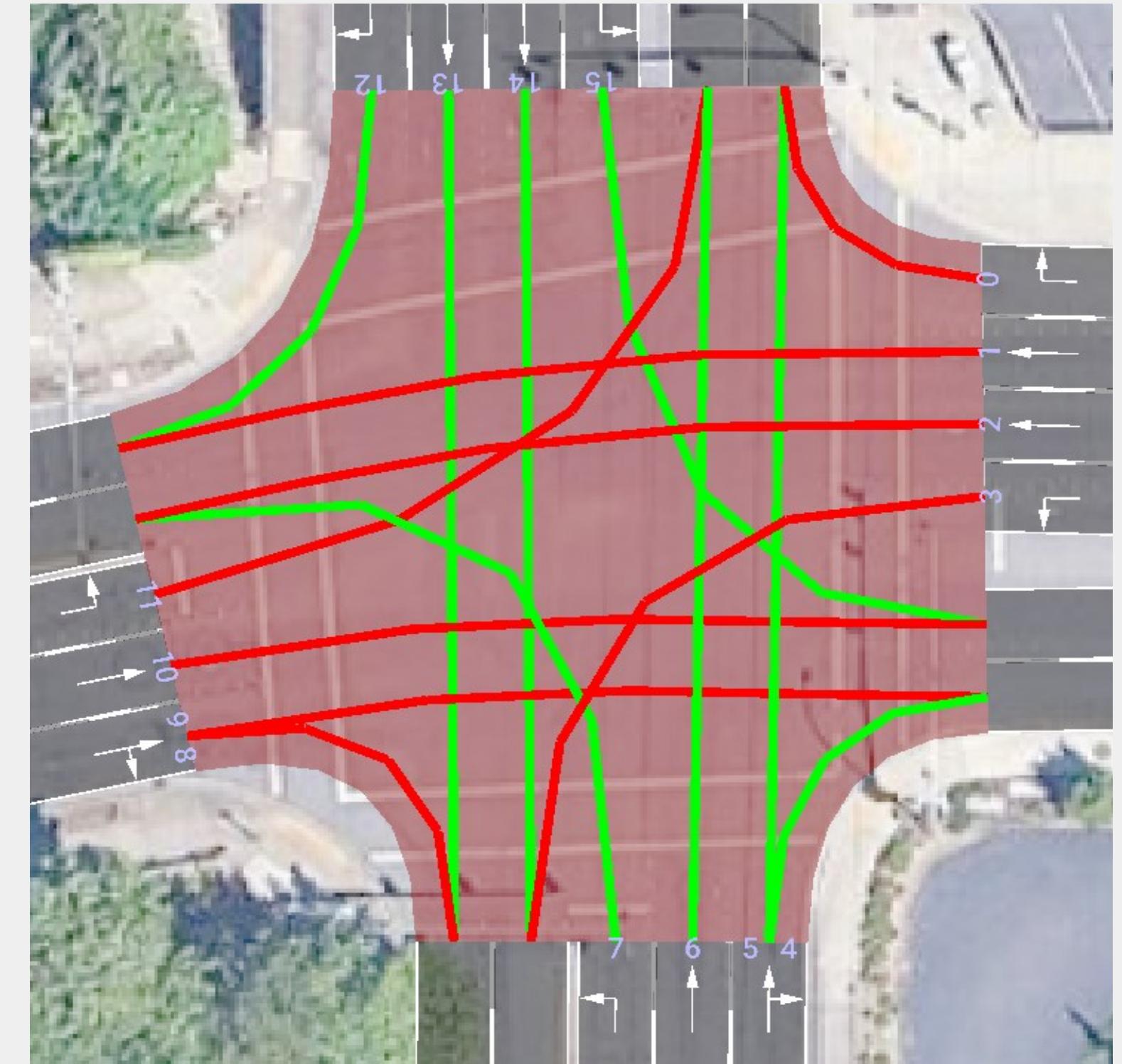
12. Set the signal phases as follows:

Phase 0: Eastbound + Westbound movements - Green

Phase 1: Eastbound + Westbound movements - Yellow (clearance)

Phase 2: Northbound + Southbound movements - Green

Phases			
dur	state	next	name
0	GGGGrrrrGGGGrrrr		
1	yyyyrrrryyyyrrrr		
2	rrrrGGGGrrrrGGGG	I	
3			
$\Sigma$			



# Traffic Signal

12. Set the signal phases as follows:

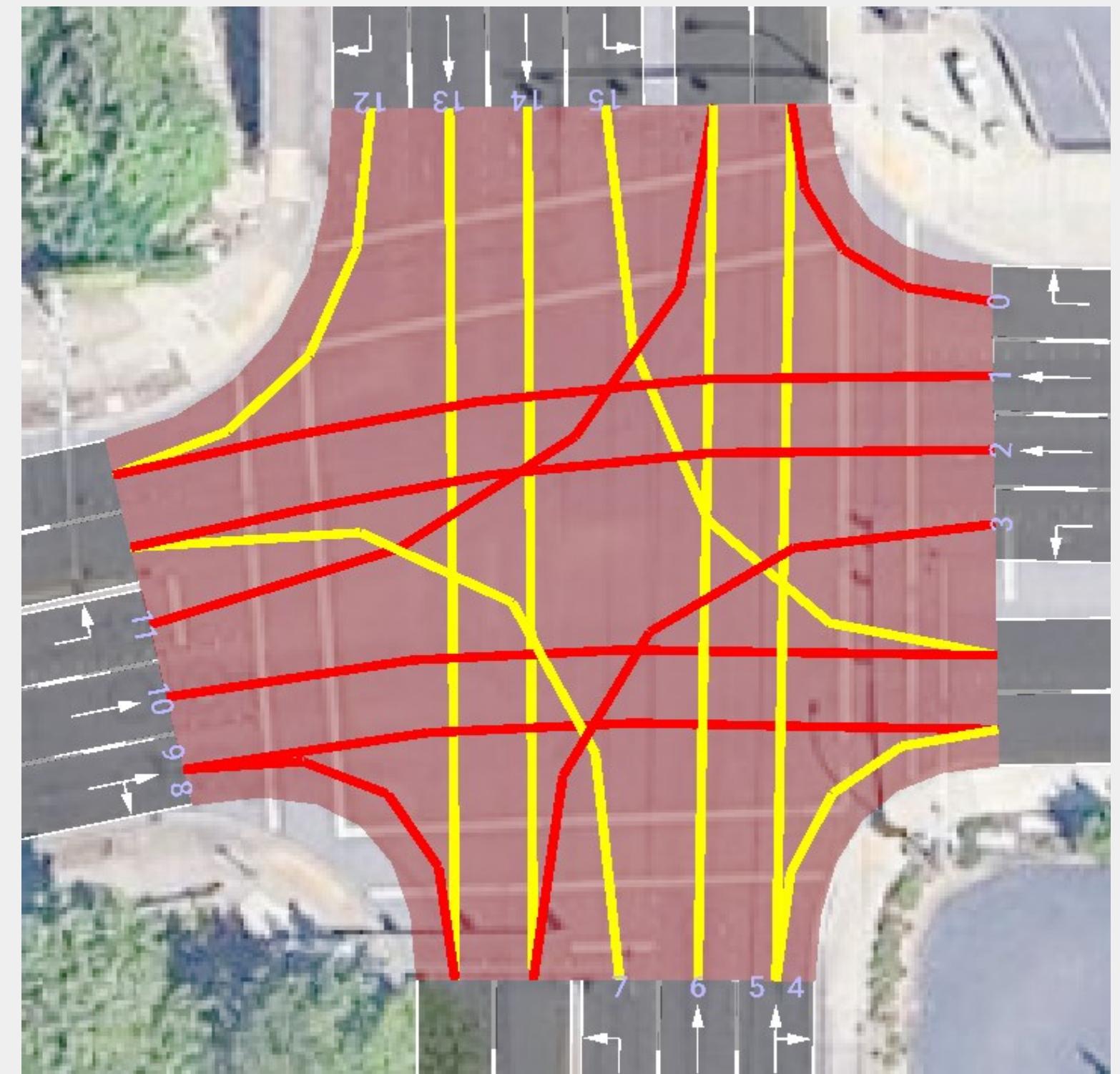
Phase 0: Eastbound + Westbound movements - Green

Phase 1: Eastbound + Westbound movements - Yellow (clearance)

Phase 2: Northbound + Southbound movements - Green

Phase 3: Northbound + Southbound movements - Yellow (clearance)

Phases			
dur	state	next	name
0	GGGGrrrrGGGGrrrr		
1	yyyyrrrryyyyrrrr		
2	rrrrGGGGrrrrGGGG		
3	rrrryyyyrrrryyyy	I	
$\Sigma$	60.00		Links: 16



# Traffic Signal

## 13. Save Files

**Edit Traffic Light**

Traffic Light

Junction ID	clusterJ14_J15_J25_J33_#4more
TLS ID	
type	static

Join Disjoin

Traffic Light Programs

programID	0
-----------	---

Duplicate Reset single  
Delete Reset all  
**Save** Cancel

Traffic Light Attributes

offset	0.00
parameters	

Assign E1 detectors

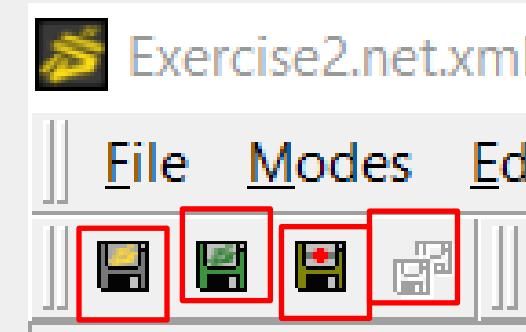
Expand Phases

	dur	state	next	name	+	X	↑	↓
0	27.00	GGGGrrrrGGGGrrrr			+ X ↑ ↓			
1	3.00	yyyyrrrryyyyrrrr			+ X ↑ ↓			
2	27	rrrrGGGGrrrrGGGG			+ X ↑ ↓			
3	3.00	rrrryyyyrrrryyyy			+ X ↑ ↓			
Σ	60.00	Links: 16						

Clean States Add States  
Group Sig. Ungroup Sig.

TLS Program File

Load Save



# Traffic Flows (Demand)

## 14. Add f\_0 flow (demand)



**Vehicles**

- flow (from-to edges)** (highlighted with a red box)
- DEFAULT\_VEHTYPE**
- Internal attributes**

id	f_0
color	yellow
departLane	first
departPos	base
departSpeed	0
arrivalLane	current
arrivalPos	max
arrivalSpeed	current
line	
personNumber	0
containerNumber	0
departPosLat	center
arrivalPosLat	center
insertionChecks	all
begin	0.00
- Flow attributes**

terminate	end
spacing	nsPerHour
end	3600.00
vehsPerHour	500



**Vehicles**

- flow (from-to edges)**
- Parent vType**
- DEFAULT\_VEHTYPE**
- Internal attributes**

id	f_0
color	yellow
departLane	first
departPos	base
departSpeed	0
arrivalLane	current
arrivalPos	max
arrivalSpeed	current
line	
personNumber	0
containerNumber	0
departPosLat	center
arrivalPosLat	center
insertionChecks	all
begin	0.00
- Flow attributes**

terminate	end
spacing	nsPerHour
end	3600.00
vehsPerHour	500
- Parameters**
- Netedit attributes**
- Route creator**
  - Selected edges: 3
  - Path edges: 6
  - Length: 385.68
  - Average speed: 13.89
  - Finish route creation** (highlighted with a red box)
  - Abort route creation
  - Remove last edge

# Traffic Flows (Demand)

## 15. Add f\_1 flow (demand)

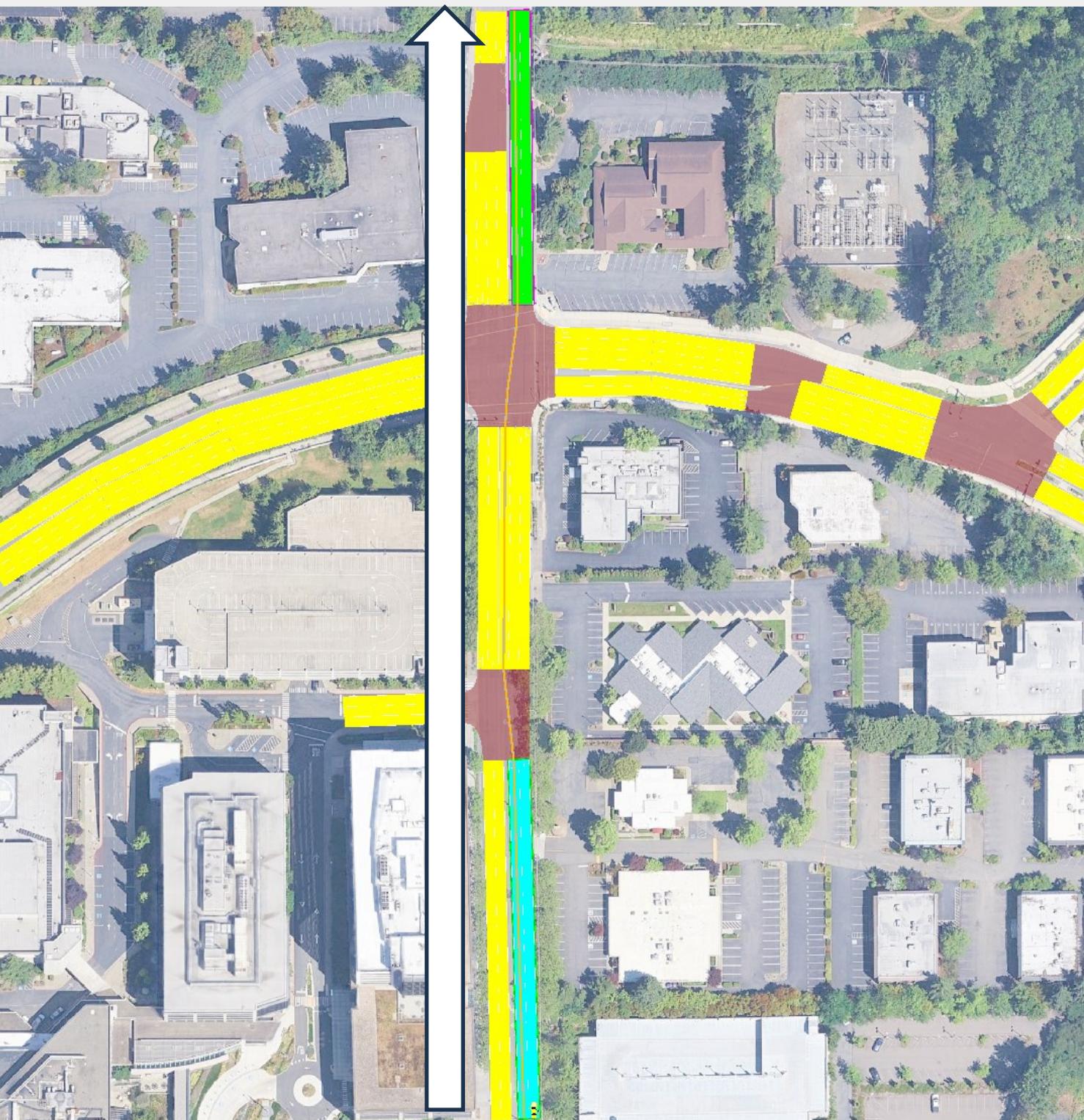


**Vehicles**

- flow (from-to edges)** (selected)
- Parent vType**
- DEFAULT\_VEHTYPE**
- Internal attributes**

id	f_1
color	yellow
departLane	first
departPos	base
departSpeed	0
arrivalLane	current
arrivalPos	max
arrivalSpeed	current
line	
personNumber	0
containerNumber	0
departPosLat	center
arrivalPosLat	center
insertionChecks	all
begin	0.00
- Flow attributes**

terminate	end
spacing	nsPerHour
end	3600.00
vehsPerHour	500



**Vehicles**

- flow (from-to edges)** (selected)
- Parent vType**
- DEFAULT\_VEHTYPE**
- Internal attributes**

id	f_1
color	yellow
departLane	first
departPos	base
departSpeed	0
arrivalLane	current
arrivalPos	max
arrivalSpeed	current
line	
personNumber	0
containerNumber	0
departPosLat	center
arrivalPosLat	center
insertionChecks	all
begin	0.00
- Flow attributes**

terminate	end
spacing	nsPerHour
end	3600.00
vehsPerHour	500
- Parameters**
- Netedit attributes**
  - route file**
- Help**
- Route creator**
  - Selected edges: 2
  - Path edges: 3
  - Length: 276.90
  - Average speed: 13.89
  - Finish route creation** (selected)
  - Abort route creation
  - Remove last edge

# Traffic Flows (Demand)

## 16. Add f\_2 flow (demand)

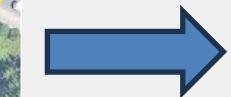
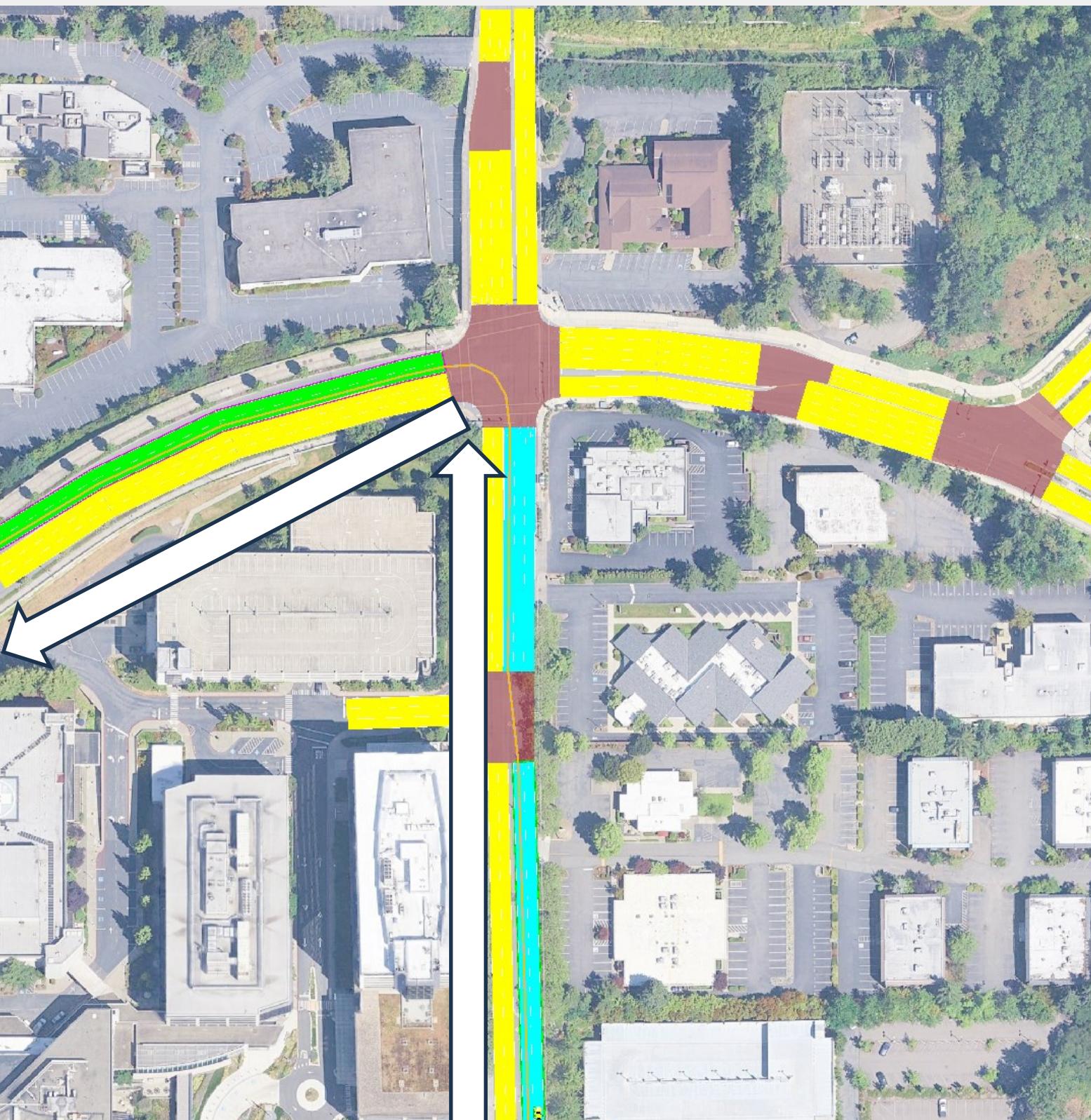


**Vehicles**

- flow (from-to edges)** (highlighted with a red box)
- Parent vType**
- DEFAULT\_VEHTYPE**
- Internal attributes**

id	f_2
color	yellow
departLane	first
departPos	base
departSpeed	0
arrivalLane	current
arrivalPos	max
arrivalSpeed	current
line	
personNumber	0
containerNumber	0
departPosLat	center
arrivalPosLat	center
insertionChecks	all
begin	0.00
- Flow attributes**

terminate	end
spacing	nsPerHour
end	3600.00
vehsPerHour	500



**Vehicles**

- flow (from-to edges)**
- Parent vType**
- DEFAULT\_VEHTYPE**
- Internal attributes**

id	f_2
color	yellow
departLane	first
departPos	base
departSpeed	0
arrivalLane	current
arrivalPos	max
arrivalSpeed	current
line	
personNumber	0
containerNumber	0
departPosLat	center
arrivalPosLat	center
insertionChecks	all
begin	0.00
- Flow attributes**

terminate	end
spacing	nsPerHour
end	3600.00
vehsPerHour	500
- Parameters**

Edit parameters
-----------------
- Netedit attributes**

route file
------------
- Help**
- Route creator**
  - Selected edges: 3
  - Path edges: 4
  - Length: 411.24
  - Average speed: 13.89
- Finish route creation** (highlighted with a red box)
- Abort route creation**
- Remove last edge**

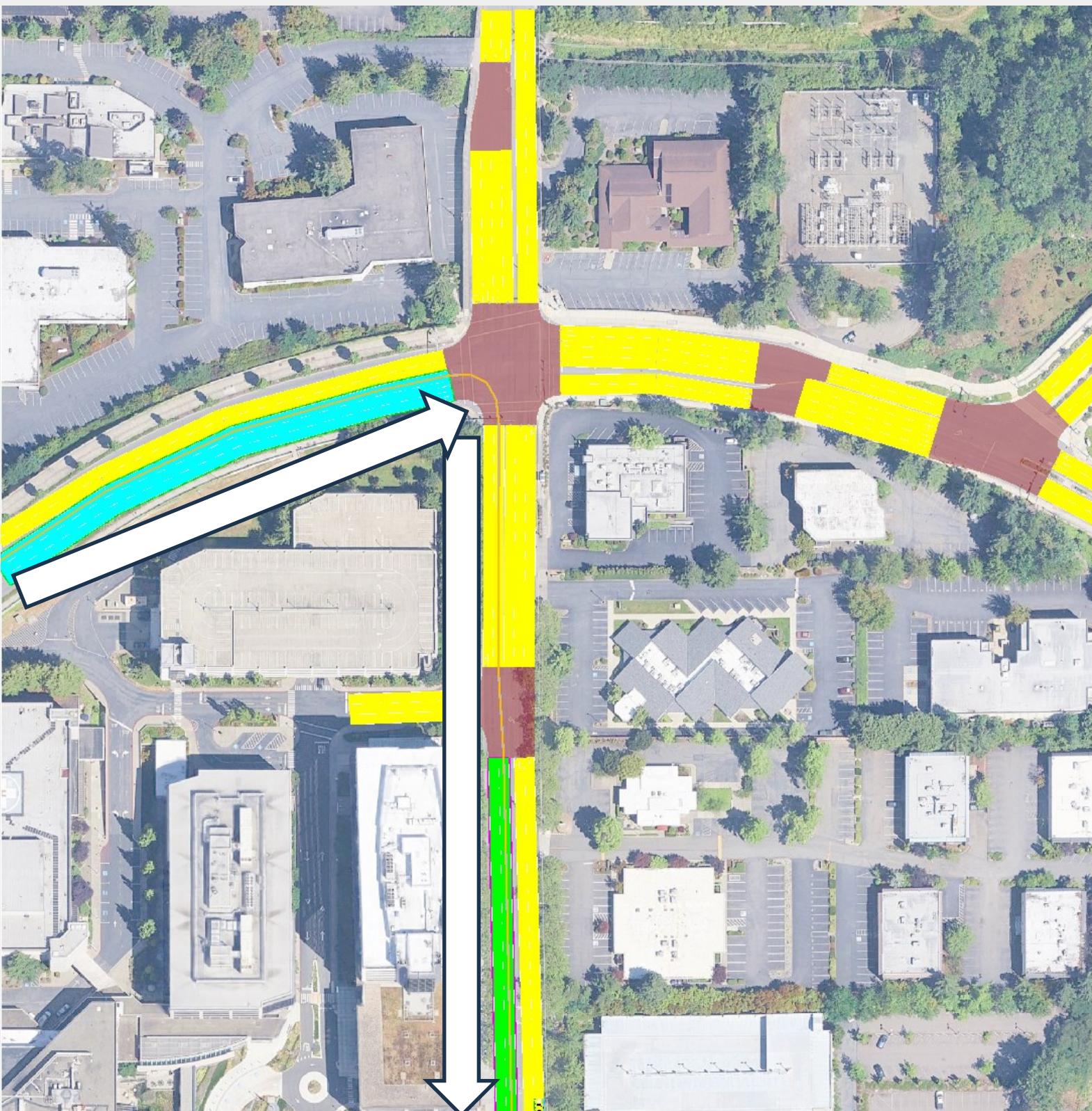
# Traffic Flows (Demand)

## 17. Add f\_3 flow (demand)



**Vehicles**

- flow (from-to edges)** (highlighted with a red box)
- DEFAULT\_VEHTYPE**
- Internal attributes**
  - id**: f\_3 (highlighted with a red box)
  - color**: yellow
  - departLane**: first
  - departPos**: base
  - departSpeed**: 0
  - arrivalLane**: current
  - arrivalPos**: max
  - arrivalSpeed**: current
  - line**
  - personNumber**: 0
  - containerNumber**: 0
  - departPosLat**: center
  - arrivalPosLat**: center
  - insertionChecks**: all
  - begin**: 0.00
- Flow attributes**
  - terminate**: end
  - spacing**: nsPerHour
  - end**: 3600.00
  - vehsPerHour**: 500 (highlighted with a red box)



**Vehicles**

- flow (from-to edges)**
- DEFAULT\_VEHTYPE**
- Internal attributes**
  - id**: f\_3
  - color**: yellow
  - departLane**: first
  - departPos**: base
  - departSpeed**: 0
  - arrivalLane**: current
  - arrivalPos**: max
  - arrivalSpeed**: current
  - line**
  - personNumber**: 0
  - containerNumber**: 0
  - departPosLat**: center
  - arrivalPosLat**: center
  - insertionChecks**: all
  - begin**: 0.00
- Flow attributes**
  - terminate**: end
  - spacing**: nsPerHour
  - end**: 3600.00
  - vehsPerHour**: 500
- Parameters**
- Netedit attributes**
  - route file**: lise2.rou.xml
- Route creator**
  - Selected edges: 2
  - Path edges: 3
  - Length: 338.55
  - Average speed: 13.89
  - Finish route creation** (highlighted with a red box)
  - Abort route creation**
  - Remove last edge**

# Traffic Flows (Demand)

## 18. Add f\_4 flow (demand)



**Vehicles**

- flow (from-to edges)** (selected)
- Parent vType**
- DEFAULT\_VEHTYPE**
- Internal attributes**
  - id**: f\_4
  - color**: yellow
  - departLane**: first
  - departPos**: base
  - departSpeed**: 0
  - arrivalLane**: current
  - arrivalPos**: max
  - arrivalSpeed**: current
  - line**
  - personNumber**: 0
  - containerNumber**: 0
  - departPosLat**: center
  - arrivalPosLat**: center
  - insertionChecks**: all
  - begin**: 0.00
- Flow attributes**
  - terminate**: end
  - spacing**: nsPerHour
  - end**: 3600.00
  - vehsPerHour**: 500



**Vehicles**

- flow (from-to edges)** (selected)
- Parent vType**
- DEFAULT\_VEHTYPE**
- Internal attributes**
  - id**: f\_4
  - color**: yellow
  - departLane**: first
  - departPos**: base
  - departSpeed**: 0
  - arrivalLane**: current
  - arrivalPos**: max
  - arrivalSpeed**: current
  - line**
  - personNumber**: 0
  - containerNumber**: 0
  - departPosLat**: center
  - arrivalPosLat**: center
  - insertionChecks**: all
  - begin**: 0.00
- Flow attributes**
  - terminate**: end
  - spacing**: nsPerHour
  - end**: 3600.00
  - vehsPerHour**: 500
- Parameters**
- Edit parameters**
- Netedit attributes**
  - route file**: route2.rou.xml
- Help**
- Route creator**
  - Selected edges: 2
  - Path edges: 4
  - Length: 276.82
  - Average speed: 13.89
  - Finish route creation** (highlighted)
  - Abort route creation**
  - Remove last edge**

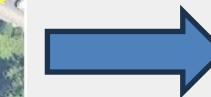
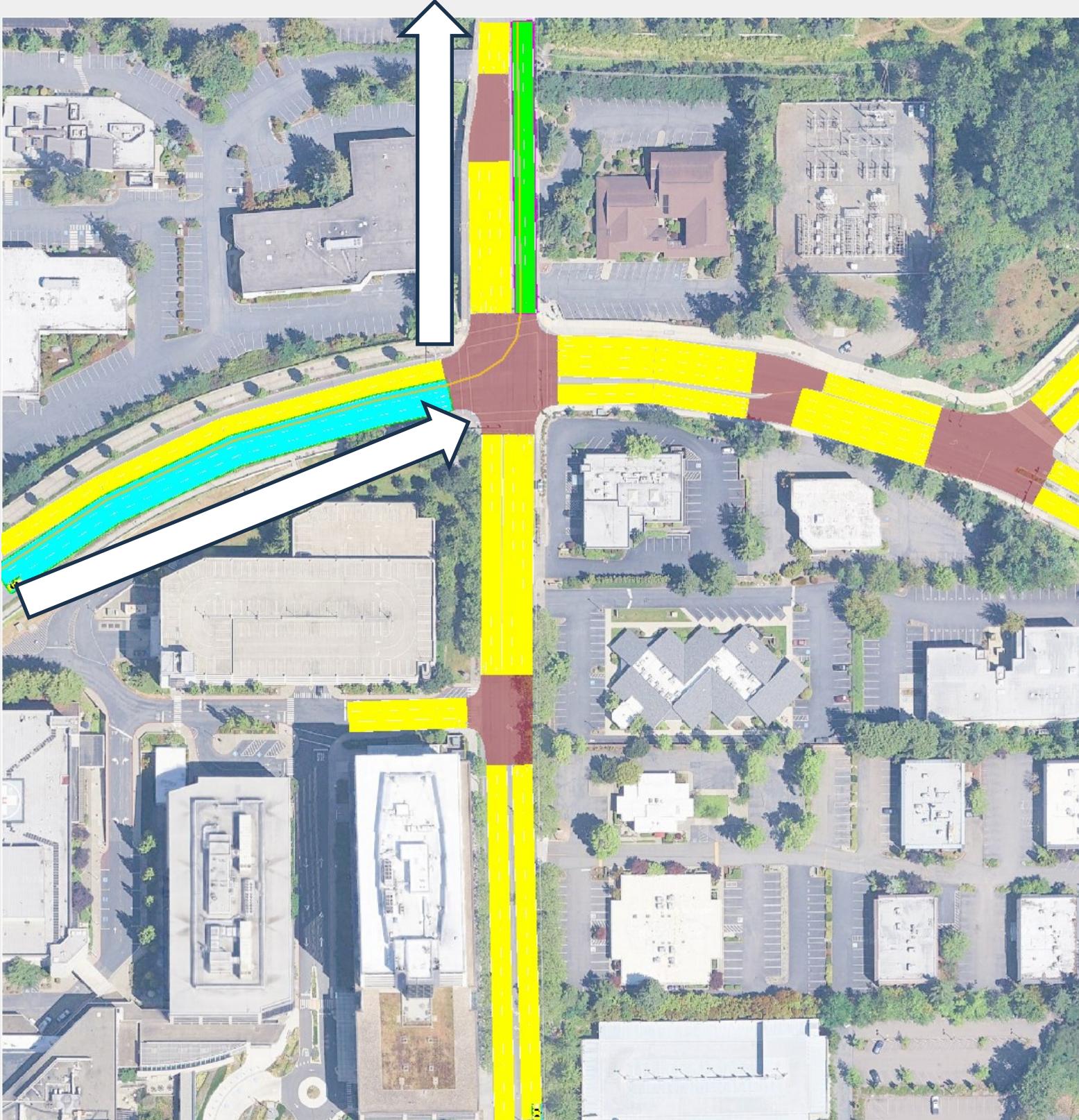
# Traffic Flows (Demand)

## 19. Add f\_5 flow (demand)



**Vehicles**

- flow (from-to edges)** (highlighted with a red box)
- DEFAULT\_VEHTYPE**
- Internal attributes**
  - id**: f\_5 (highlighted with a red box)
  - color**: yellow
  - departLane**: first
  - departPos**: base
  - departSpeed**: 0
  - arrivalLane**: current
  - arrivalPos**: max
  - arrivalSpeed**: current
  - line**
  - personNumber**: 0
  - containerNumber**: 0
  - departPosLat**: center
  - arrivalPosLat**: center
  - insertionChecks**: all
  - begin**: 0.00
- Flow attributes**
  - terminate**: end
  - spacing**: nsPerHour
  - end**: 3600.00
  - vehsPerHour**: 500 (highlighted with a red box)

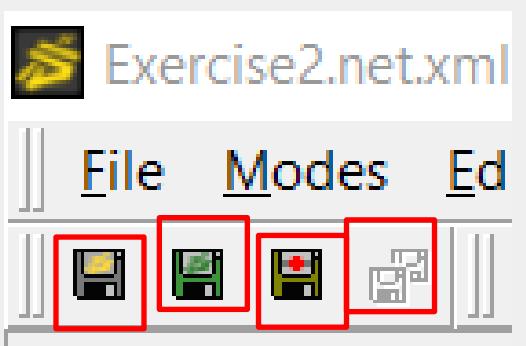


**Vehicles**

- flow (from-to edges)**
- DEFAULT\_VEHTYPE**
- Internal attributes**
  - id**: f\_5
  - color**: yellow
  - departLane**: first
  - departPos**: base
  - departSpeed**: 0
  - arrivalLane**: current
  - arrivalPos**: max
  - arrivalSpeed**: current
  - line**
  - personNumber**: 0
  - containerNumber**: 0
  - departPosLat**: center
  - arrivalPosLat**: center
  - insertionChecks**: all
  - begin**: 0.00
- Flow attributes**
  - terminate**: end
  - spacing**: nsPerHour
  - end**: 3600.00
  - vehsPerHour**: 500
- Parameters**
- Edit parameters**
- Netedit attributes**
  - route file**: route2.rou.xml
- Help**
- Route creator**
  - Selected edges: 2
  - Path edges: 2
  - Length: 243.04
  - Average speed: 13.89
- Finish route creation** (highlighted with a red box)
- Abort route creation**
- Remove last edge**

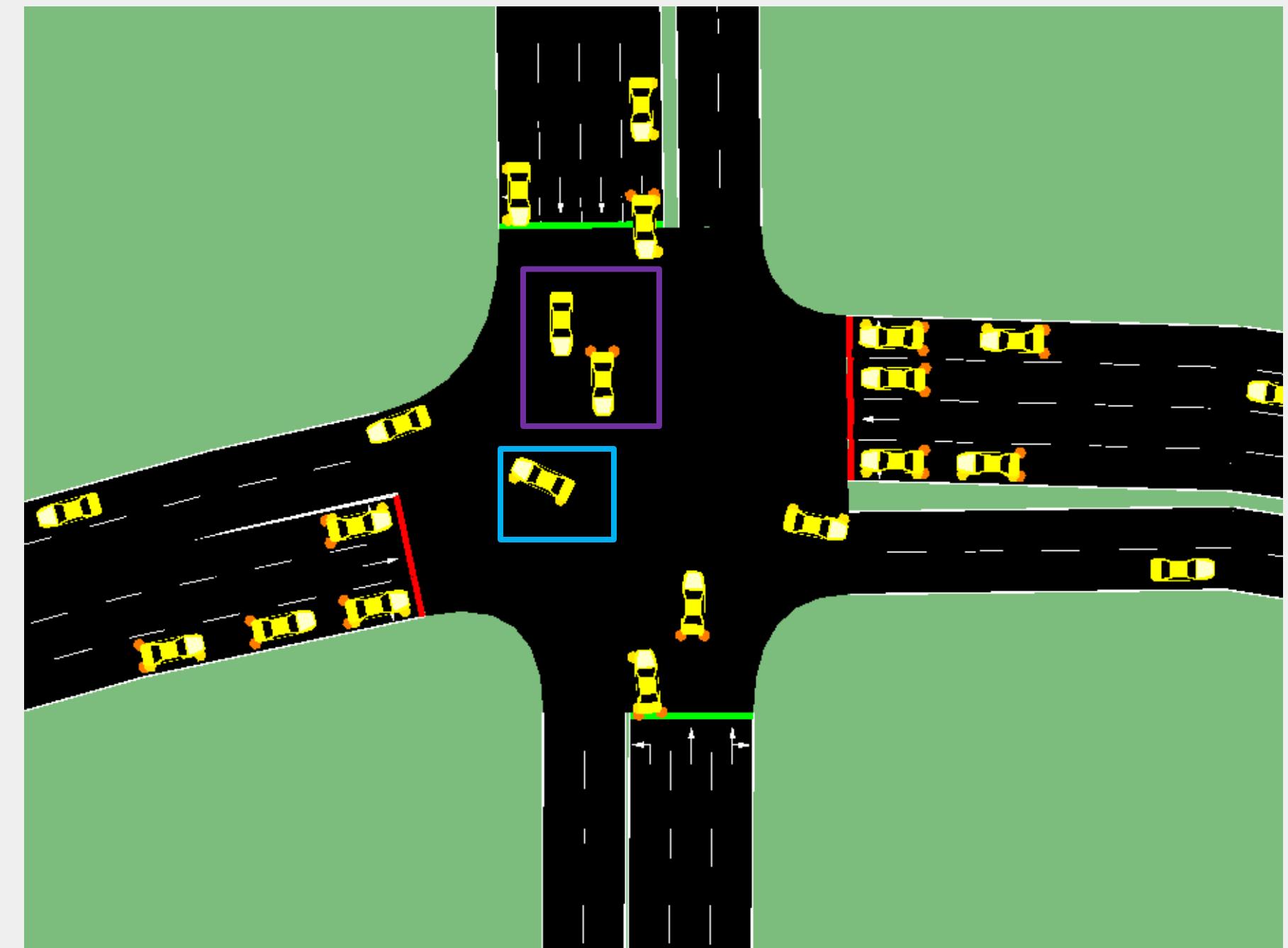
# Traffic Flows (Demand)

- Add f\_6, f\_7, and f\_8 for the southbound approach
- Add f\_9, f\_10, and f\_11 for the westbound approach
- Save all files



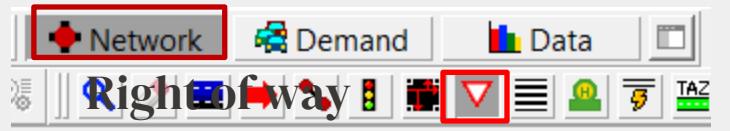
# Traffic Signal

- Run the SUMO Gui
- You will notice that left-turn movement is incorrectly given right of way over the through movement.

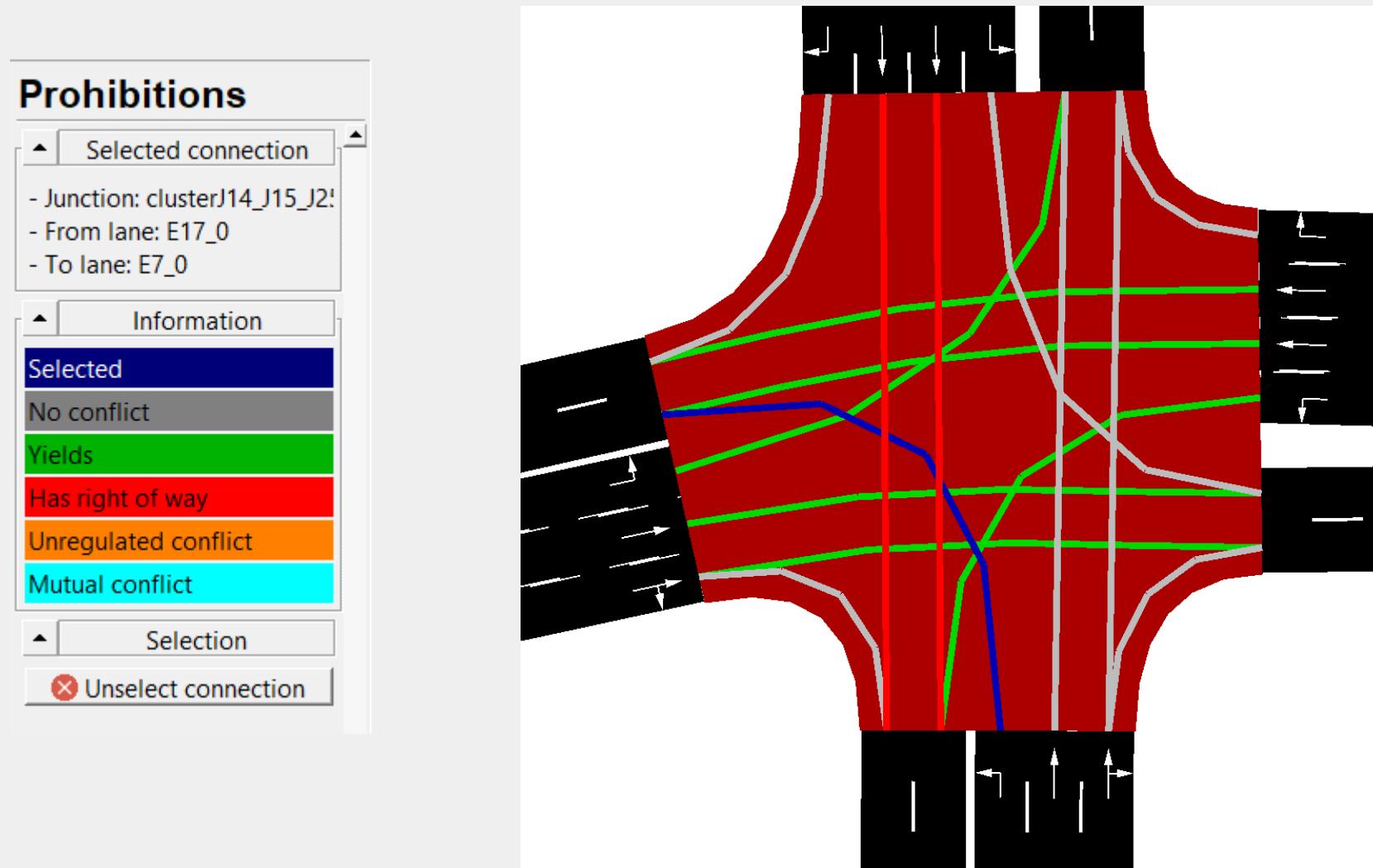


# Traffic Signal

Open Netedit



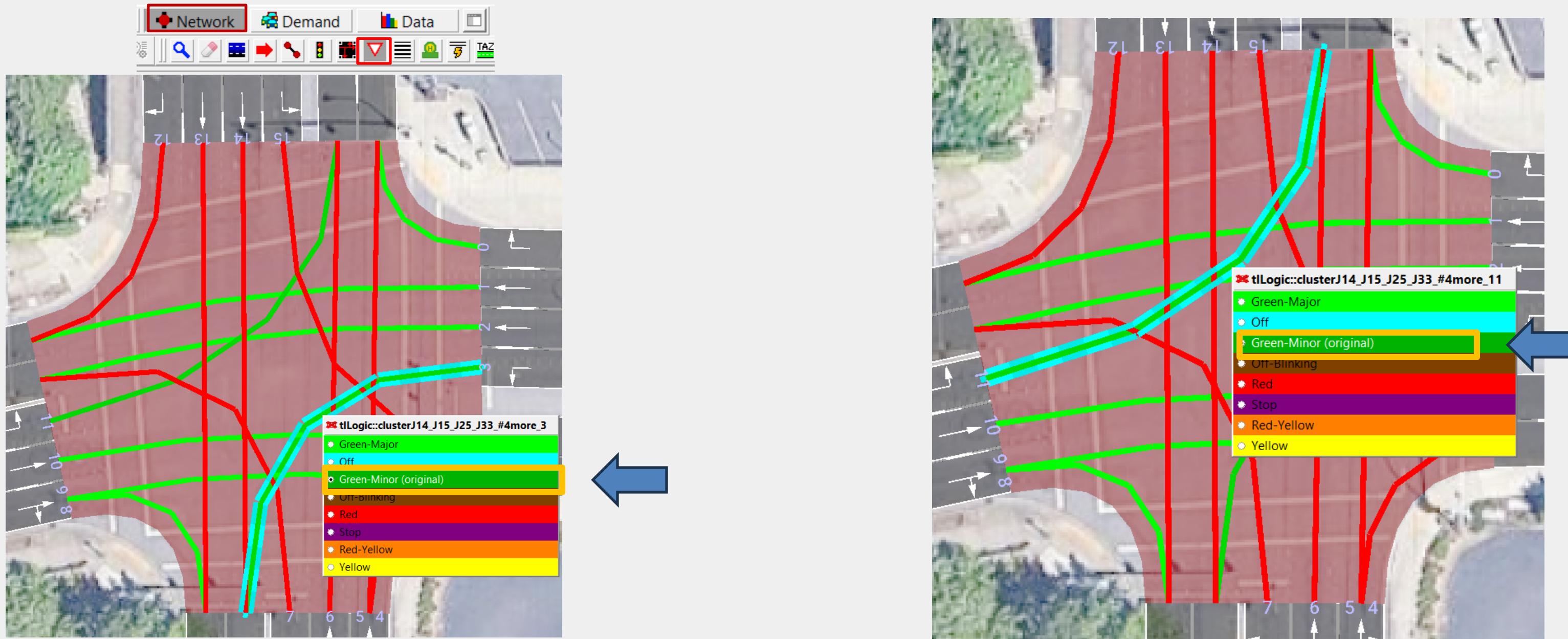
Select the connection



- Traffic on the **blue connection** **yields to the green connection**
- Traffic on the **blue connection** **has right of way** over the **red connection**

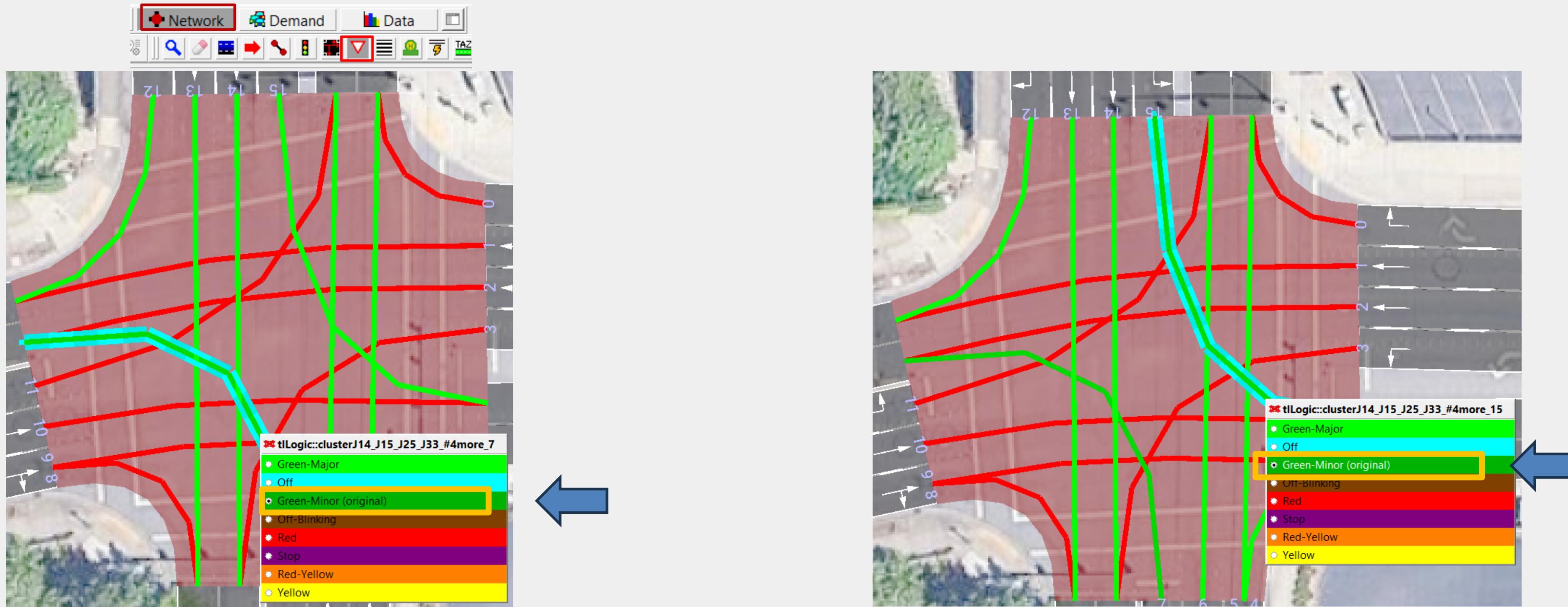
# Traffic Signal

- Right-click the left-turn connections and set them to Green-Minor during their green phases.



# Traffic Signal

- Right-click the left-turn connections and set them to Green-Minor (green phases only).



# Traffic Signal

## Save Files

**Edit Traffic Light**

**Traffic Light**

Junction ID	clusterJ14_J15_J25_J33_#4more
TLS ID	
type	static

**Traffic Light Programs**

programID	0
-----------	---

**Traffic Light Attributes**

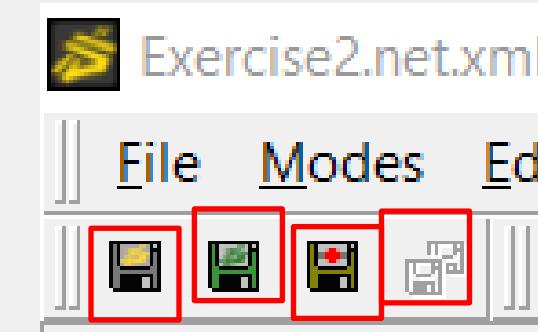
offset	0.00
parameters	

[Assign E1 detectors](#)

**Expand**

	dur	state	next	name
0	27.00	GGGgrrrrGGGgrrrr		
1	3.00	yyyyrrrryyyyrrrr		
2	27.00	rrrrGGGgrrrrGGGg		
3	3.00	rrrryyyyrrrryyyy		
$\Sigma$	60.00	Links: 16		

**TLS Program File**



# Traffic Signal

- Run the SUMO Gui
- Verify that left-turn movements yield to through movements

