Supplemental Guidance for Modeling Signalized Interchanges, Intersections and Roundabouts from NCHRP Report 791

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NCHRP Report 791, *Supplemental Guidance on the Application of FHWA's Traffic Noise Model (TNM)*

(NCHRP Project 25-34)

1.	Structure Reflected Noise
2.	Bridge Expansion Joints
3.	Signalized Interchanges
4.	Intersections
5.	Area Sources
6.	Median Barriers
7.	Roundabouts
8.	Multi-lane Highways
9.	Rows of Buildings
10.	Topography
11.	Wind Direction
12.	Temperature Inversion
13.	Ground Zones
14.	Tree Zones
15.	Parallel Barriers
16.	Tunnel Openings

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Issues

- Over-modeling or micro-modeling may not improving accuracy of results

- Under-modeling may miss potentially important effects on levels when noise-sensitive receptors are nearby

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Concepts - acceleration

- **Acceleration is computed by TNM**
  - Designate roadway as "flow control" using "Control Device" choice
  - TNM computes changing speed and "full throttle" REMELs based on starting speed ("Speed Constraint"), desired final speed and grade

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Full-throttle REMELs for autos

A-weighted Noise Emissions
Automobiles: Full Throttle

Cruise REMEL

From TNM Technical Manual

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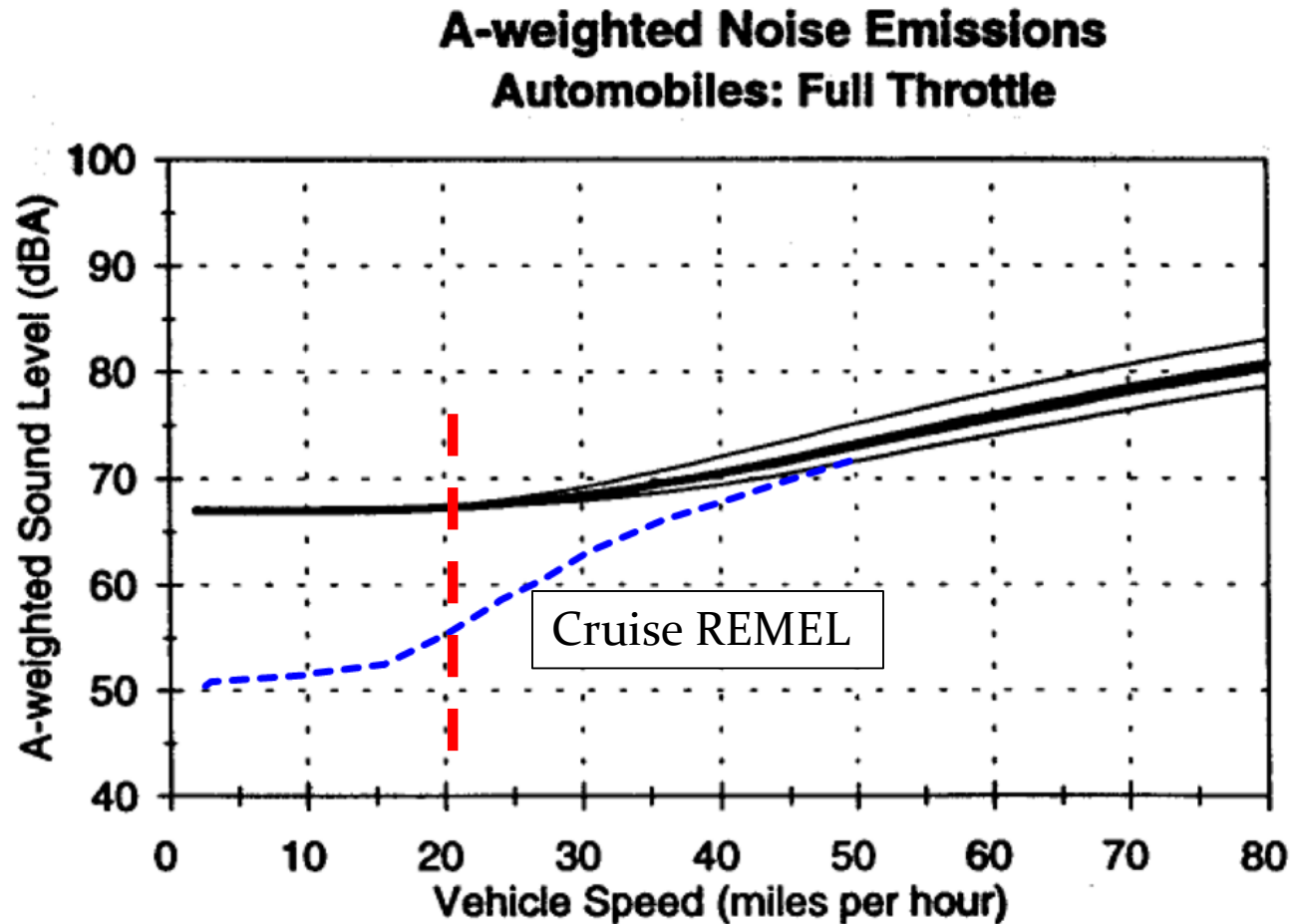
Flow-control roadway segment lengths

- Do not exceed 50 ft if final cruise speed is 30 mph, 100 ft for 45 mph, and 500 ft for 60 mph or higher.

Roadway 22
1.9%up
1.0%up
2.0%down
0.0%
End computing speeds
Begin computing speeds
Traffic-control device
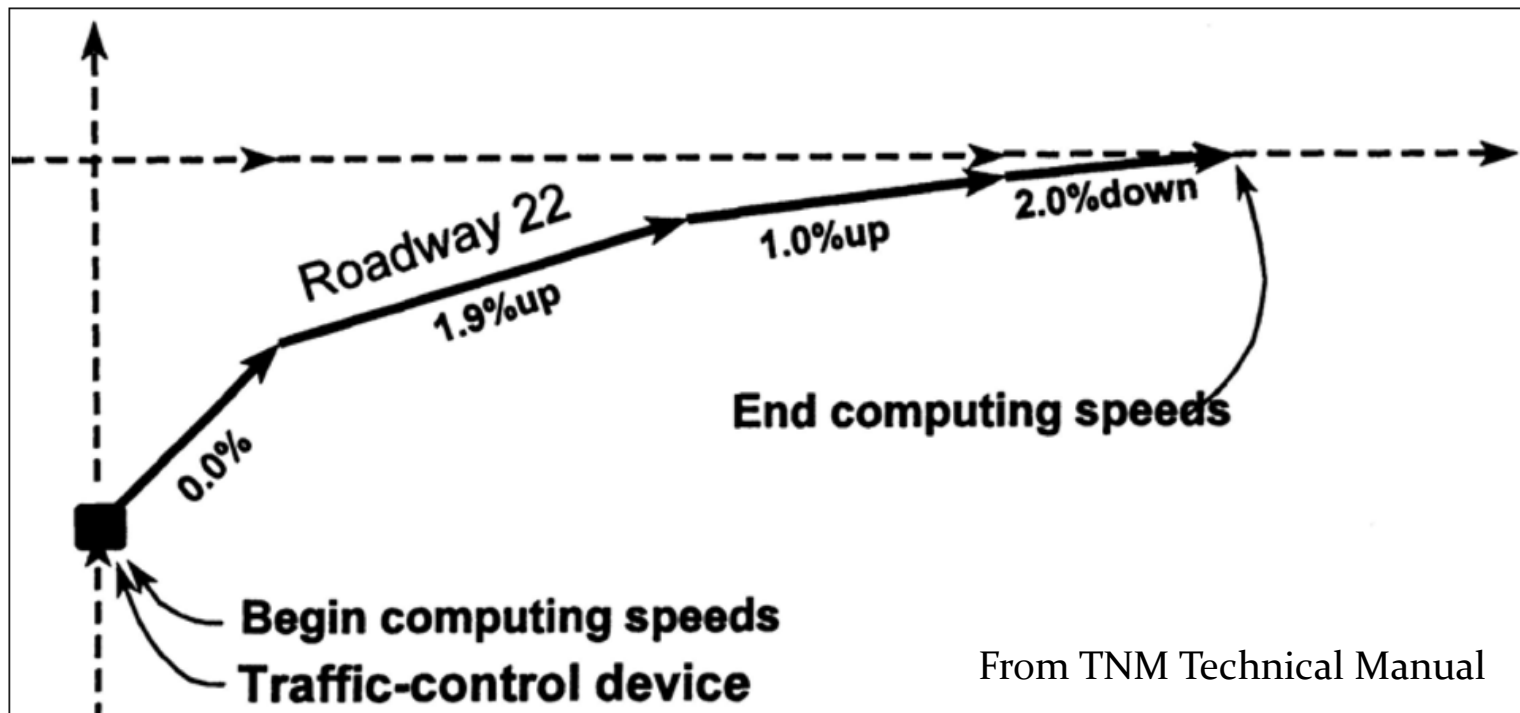
From TNM Technical Manual

Concepts - deceleration

- **Deceleration is not computed by TNM (except for heavy trucks *cruising* up a grade >1.5%)**
  - Use as a foundation the guidance in NCHRP Report 311, *Predicting Stop-and-Go Traffic Noise Levels**

Constant Speed Approach   ZOI(1)   ZOI(2)   End of Deceleration Roadway   Acceleration Roadway
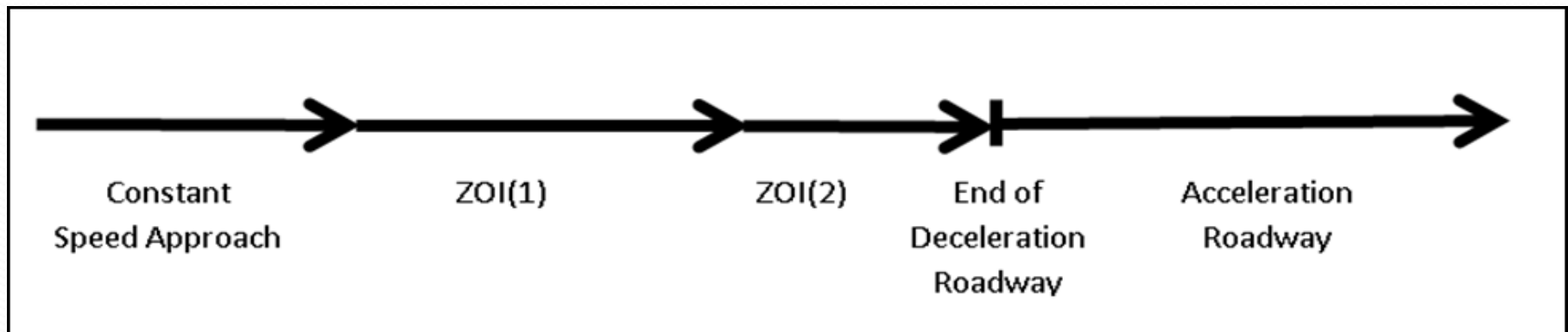
* Bowlby, W., R.L. Wayson and R.E. Stammer, Jr., *Predicting Stop-and-Go Traffic Noise Levels*, NCHRP Report 311, Transportation Research Board, Washington, D.C., 1989.
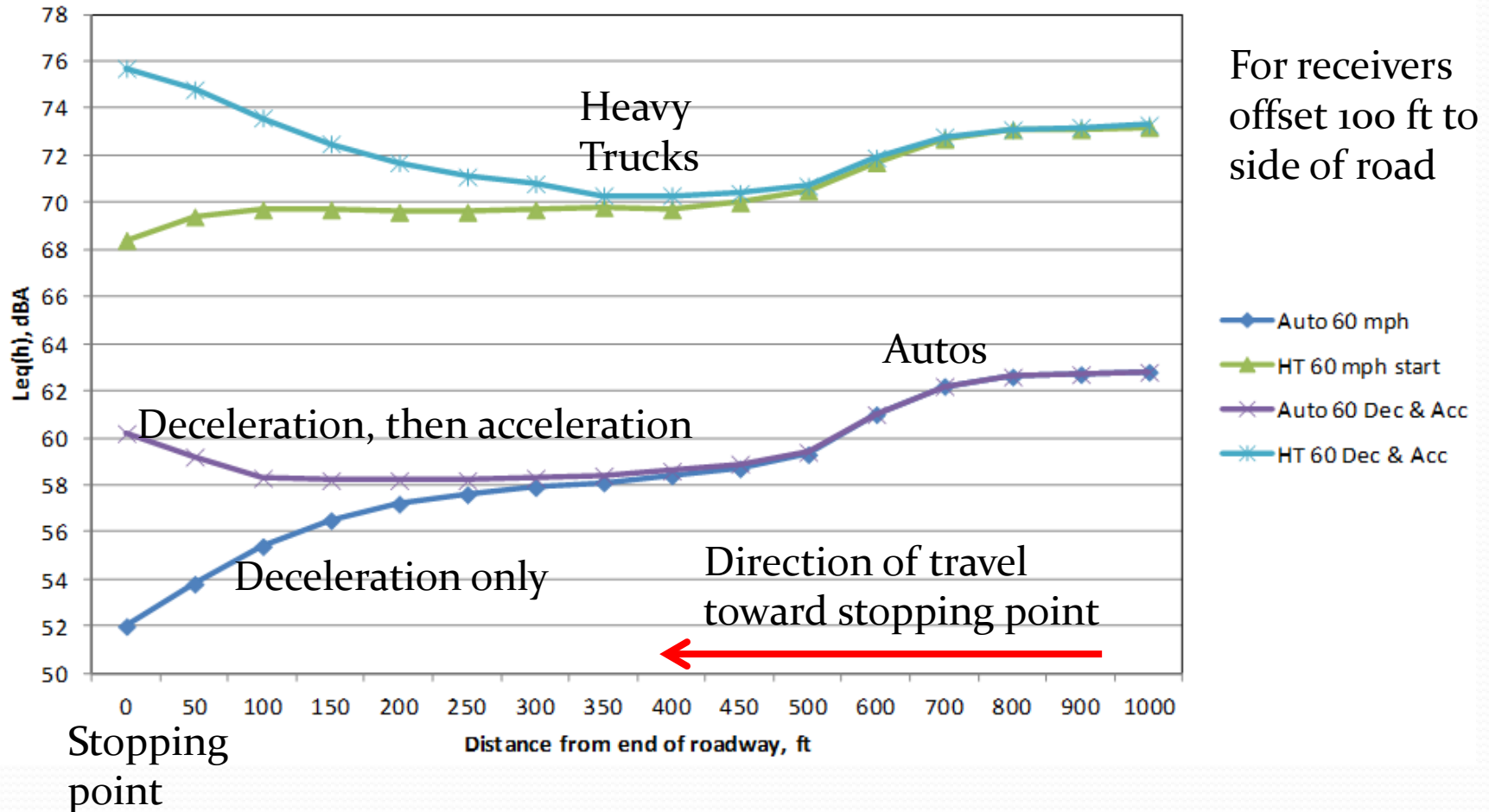
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Deceleration guidance

- For cruise speed of 40 mph and below: model as a constant-speed cruise roadway as a conservative approach, even for receivers close to the stop line

- For higher speeds, computed level differences suggest modeling with lower-speed segments, especially for small heavy truck percentages

- ***This guidance does not consider contribution to receiver sound levels from downstream traffic or traffic on a cross street***
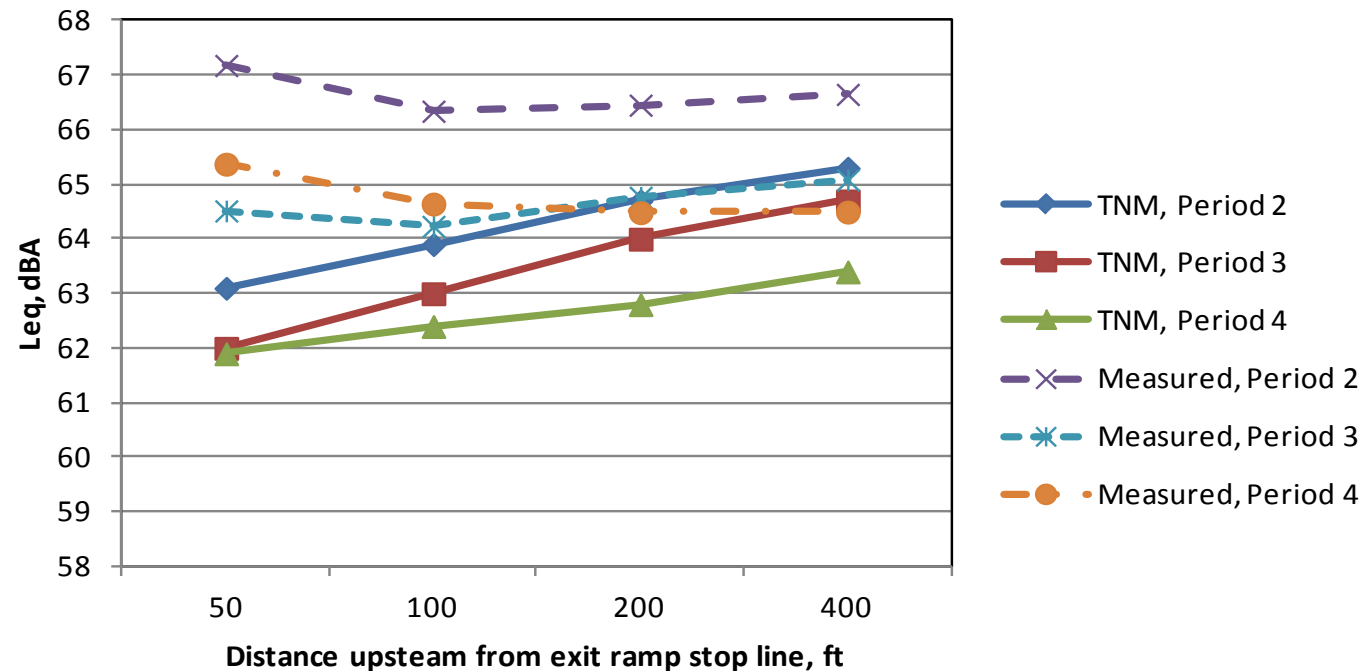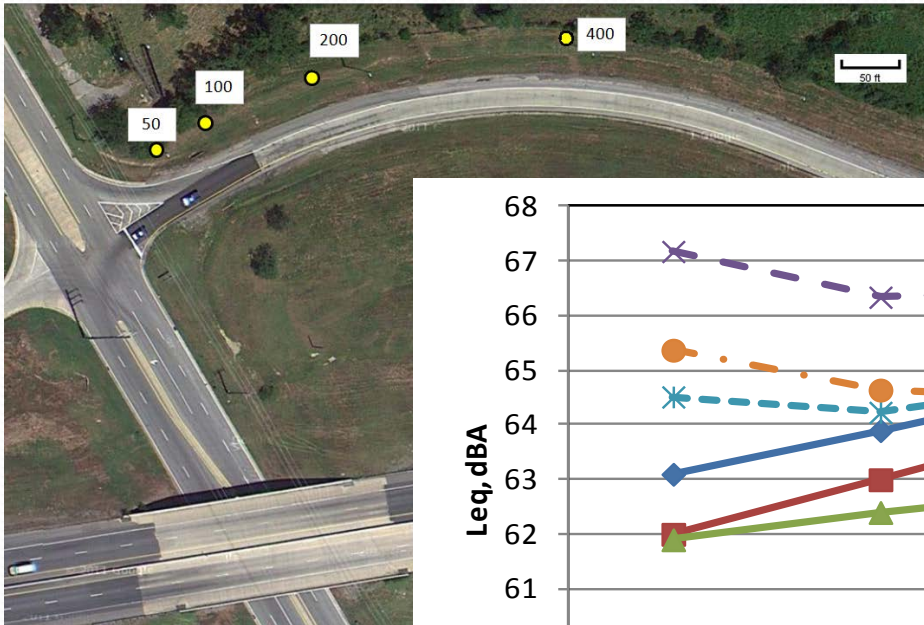
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Guidelines for Modeling Deceleration Roadways with Final Speed of 0 mph

Deceleration Range (mph)		Length (ft)		Speed, ZOI(1) (mph)			Speed ZOI(2) (mph)		
$S_{initial}$	S_{final}	ZOI(1)	ZOI(2)	Autos	MT	HT	Autos	MT	HT
NCHRP Report 311									
30	0	150	100	29	26	24	~~18~~	~~13~~	~~10~~
40	0	275	100	34	30	28	~~18~~	~~13~~	~~10~~
50	0	400	100	38	34	31	~~18~~	~~13~~	~~10~~
~~60~~	~~0~~	~~500~~	~~100~~	~~41~~	~~36~~	~~33~~	~~18~~	~~13~~	~~10~~
NCHRP Report 791									
60	**0**	**500**	**100**	**50**	**50**	**35**	**20**	**20**	**20**

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Effect of acceleration from end of exit ramp (60 mph starting speed)

For receivers offset 100 ft to side of road

Heavy Trucks

Autos

Deceleration, then acceleration

Deceleration only

Direction of travel toward stopping point

Stopping point

Auto 60 mph
HT 60 mph start
Auto 60 Dec & Acc
HT 60 Dec & Acc

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Measurements show upstream effects of acceleration noise

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Signalized interchanges
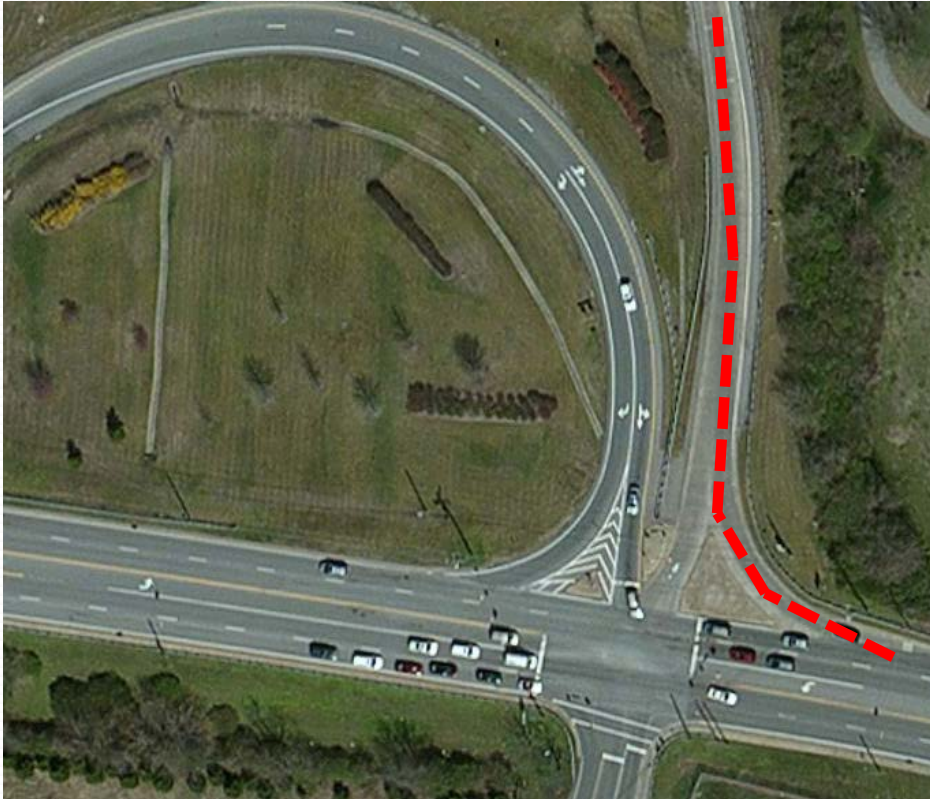
- Traditional diamond interchange
- Single-point urban interchange (SPUI)


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Entrance ramp

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- Model as a flow control acceleration roadway that starts at the beginning of the ramp
- 100% Vehicles Affected
- Speed Constraint = 10 mph, based on NCHRP Report 311 recommendation for heavy trucks

Entrance ramp roadway length

- Ok to end ramp TNM roadway at physical merge point
  - Unless ramp truck traffic is a very large percentage of mainline truck traffic (40% at 50 mph, 16% at 70 mph)
  - Sufficient to have TNM accelerate heavy trucks up to 30 mph (approx. 700 ft on a 0% grade)

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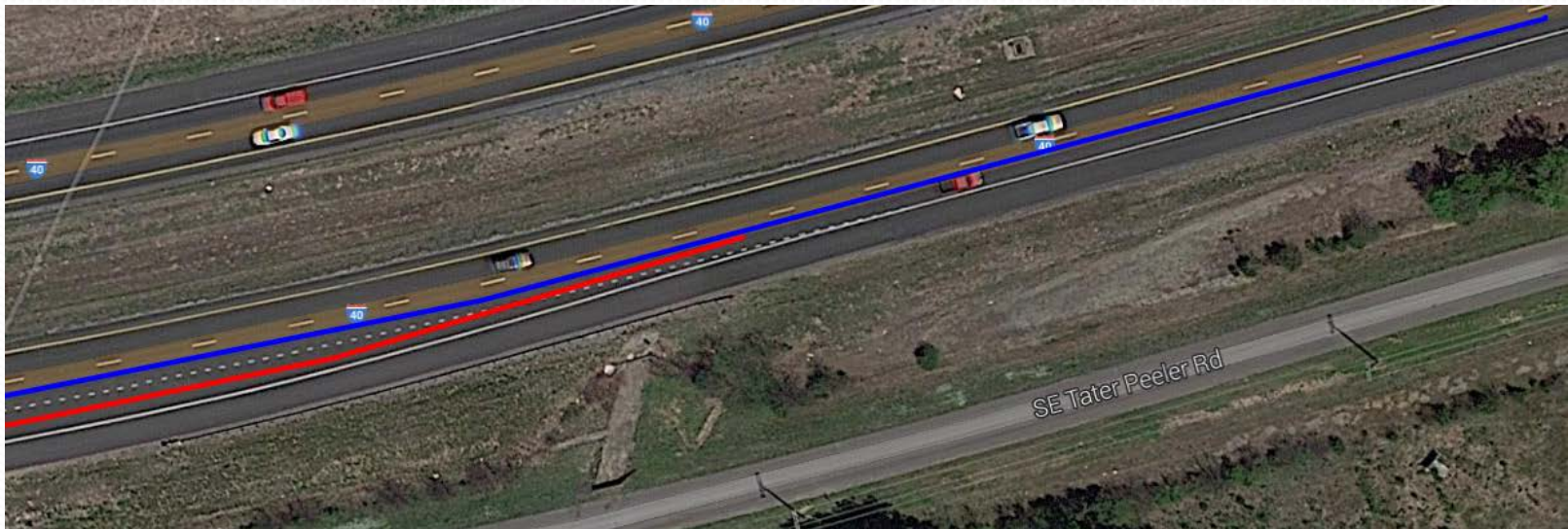
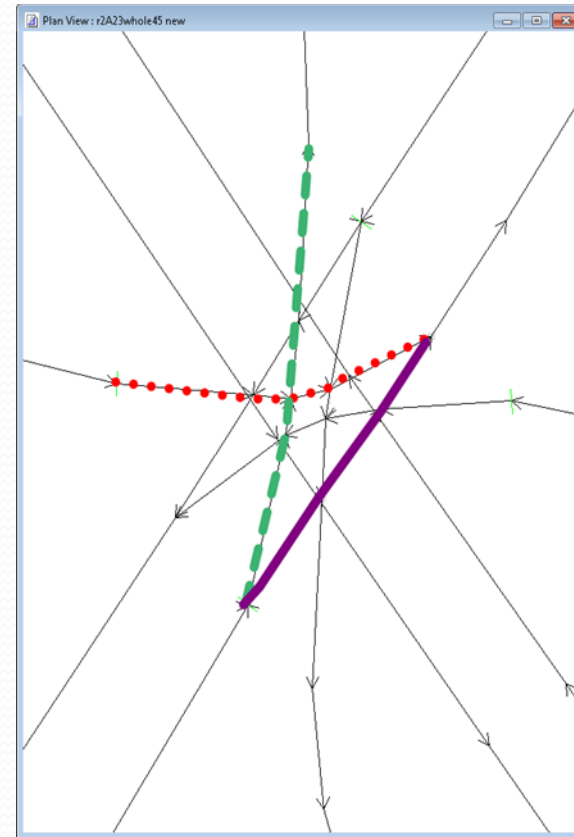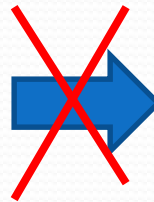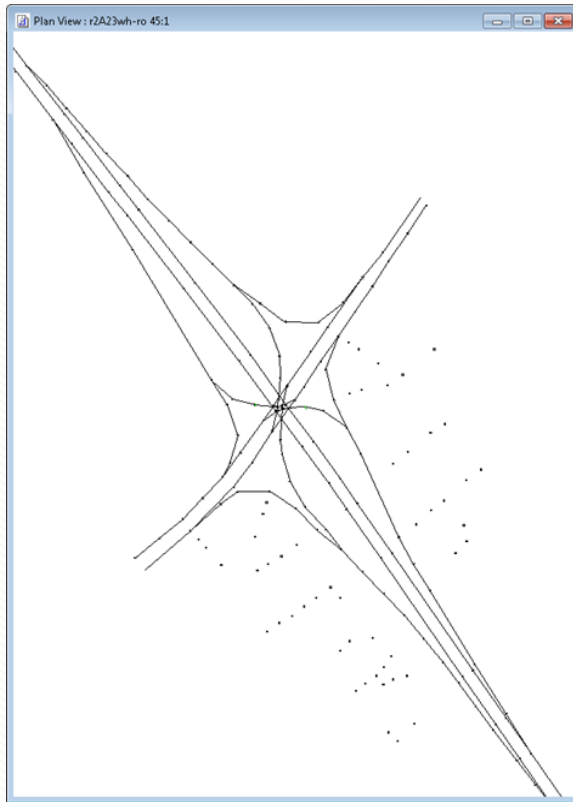# Exit ramp modeling – influencing factors

- Mainline noise may dominate total sound level for receivers along ramp, based on:
  - Receiver offset distance
  - Distance upstream
  - Ramp traffic percentage of mainline traffic
- Accelerating traffic at end of ramp affects upstream levels:
  - Stop sign or channelization at end of ramp
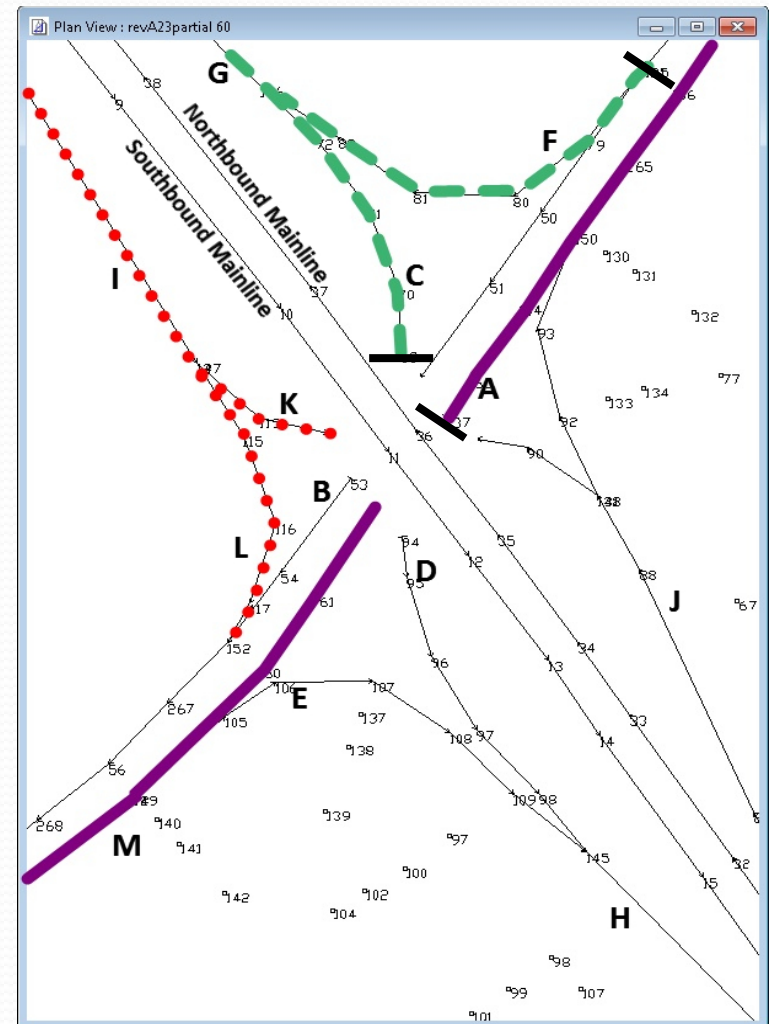 - Queue on signal-controlled ramp

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Imagery © 2014 Google, Map data © 2014 Google
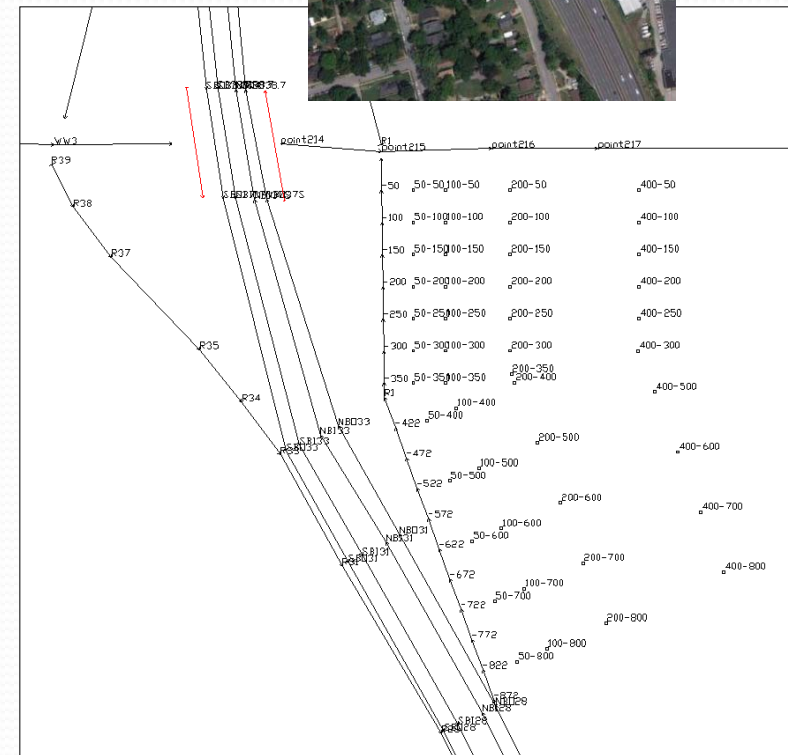
Single point urban interchange

- Full modeling is generally not necessary
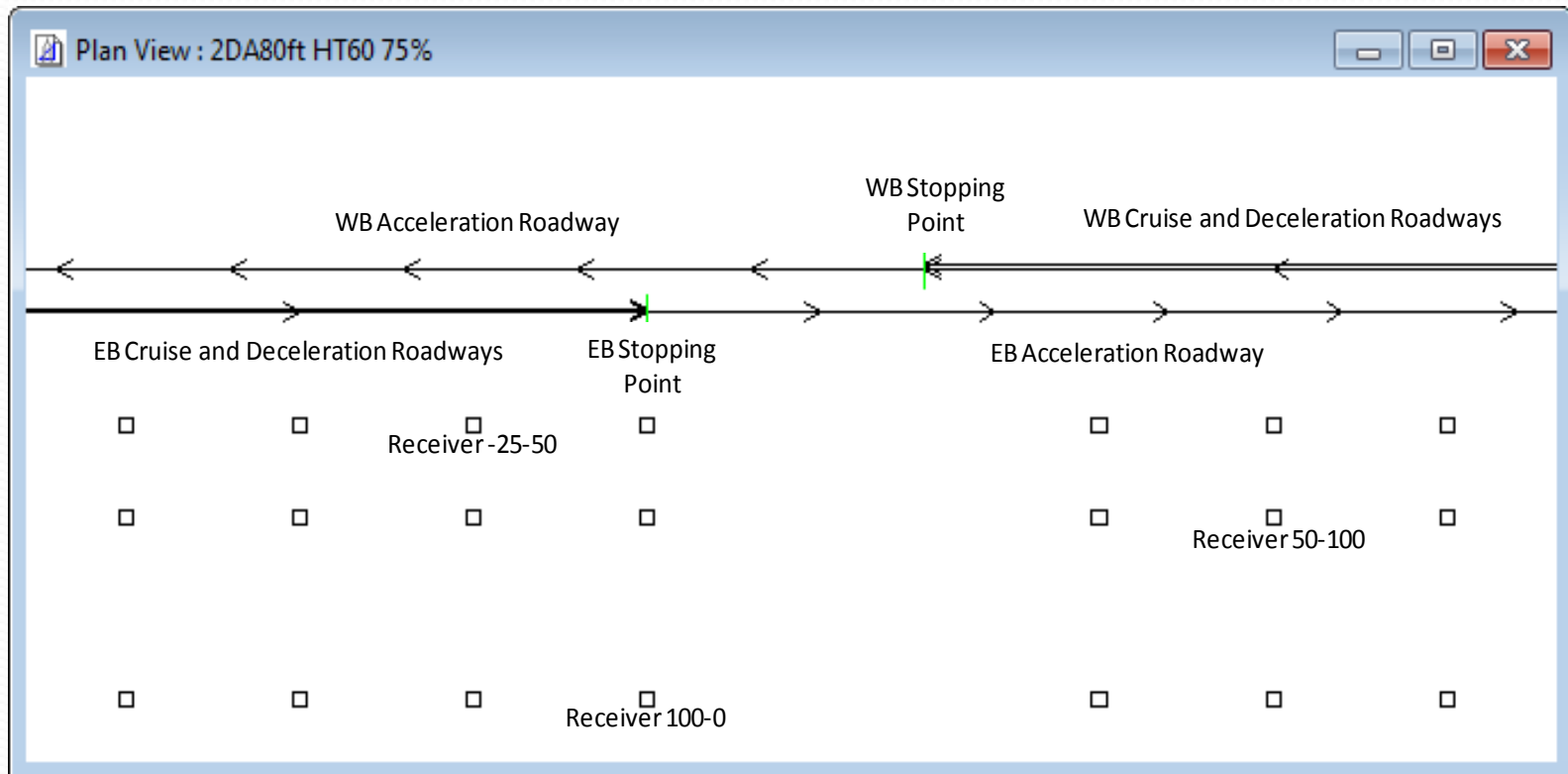
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Single point urban interchange

- Partial modeling avoids all intersecting points
- Speed constraint = 20 mph
- 50% "Vehicles Affected" for left turn entrance ramp ("C") and through roadway ("A")
- 100% "Vehicles Affected" for right turn entrance ramp ("F")

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Intersections

- Signalized and unsignalized intersections, one- and two-way

Plan View : 2DA80ft HT60 75%

WB Acceleration Roadway

WB Stopping Point

WB Cruise and Deceleration Roadways

EB Cruise and Deceleration Roadways

EB Stopping Point

EB Acceleration Roadway

Receiver -25-50

Receiver 50-100

Receiver 100-0

Unsignalized intersection – four-way stop

- Main or most important road
  - Approach roadway: constant-speed roadway at posted speed
  - Flow control roadway starting at stop line: Speed Constraint = 0 mph; 100% Vehicles Affected
- Intersecting road: do not need to model crossing through intersection
  - Approach: constant-speed roadway at posted speed
  - Departure: flow control roadway: 100% Vehicles Affected and Speed Constraint = 15-20 mph
- Maybe more detail if close to impact criterion

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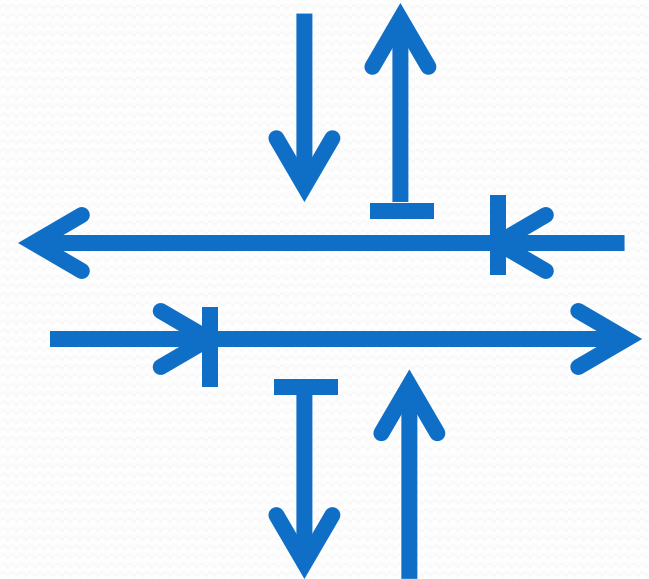
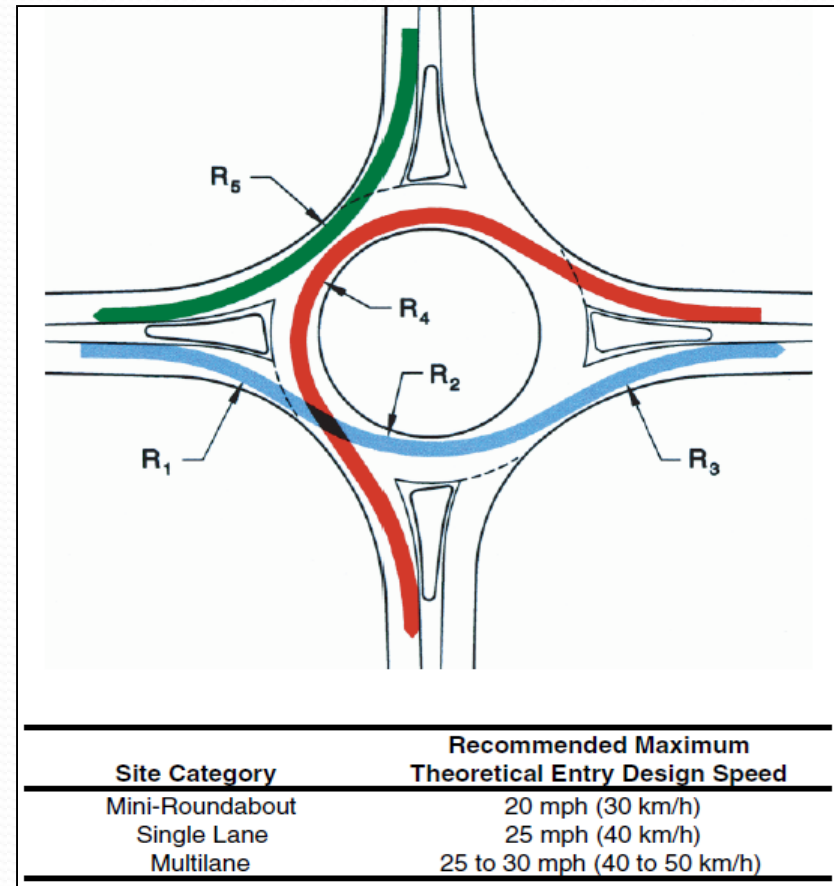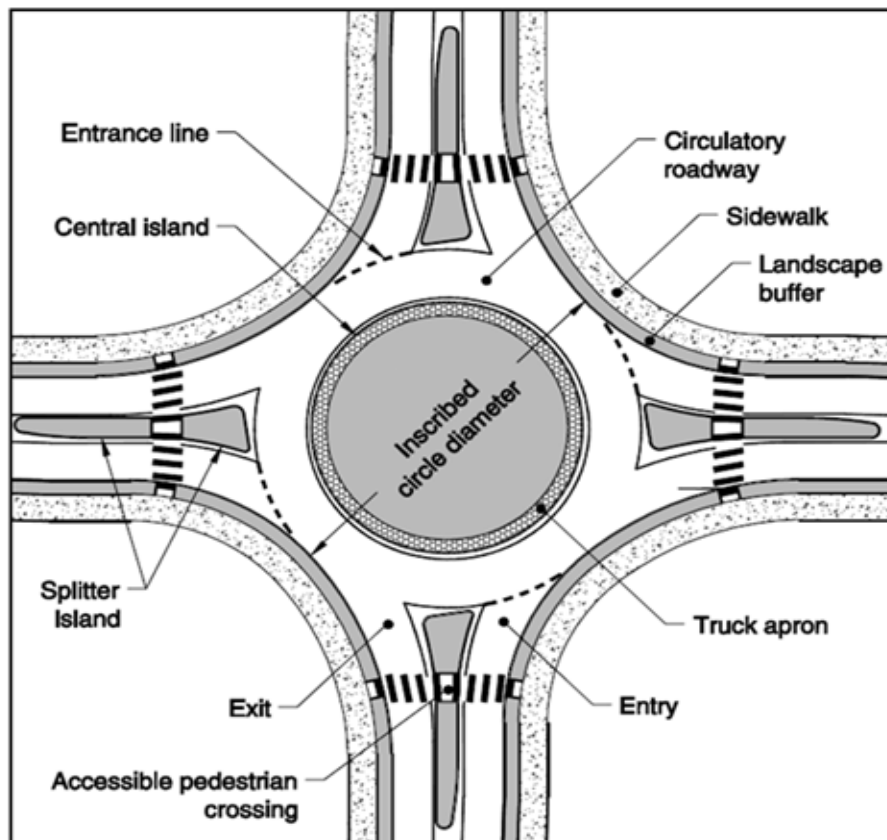# Signalized intersection (for two-way traffic)

- Main road is similar to 4-way stop, except:
  - End approach roadway and start flow-control roadway halfway back the expected queue from stop line
  - 50% Vehicles Affected
- Intersecting road: do not cross through intersection
  - Approach: constant-speed roadway at posted speed
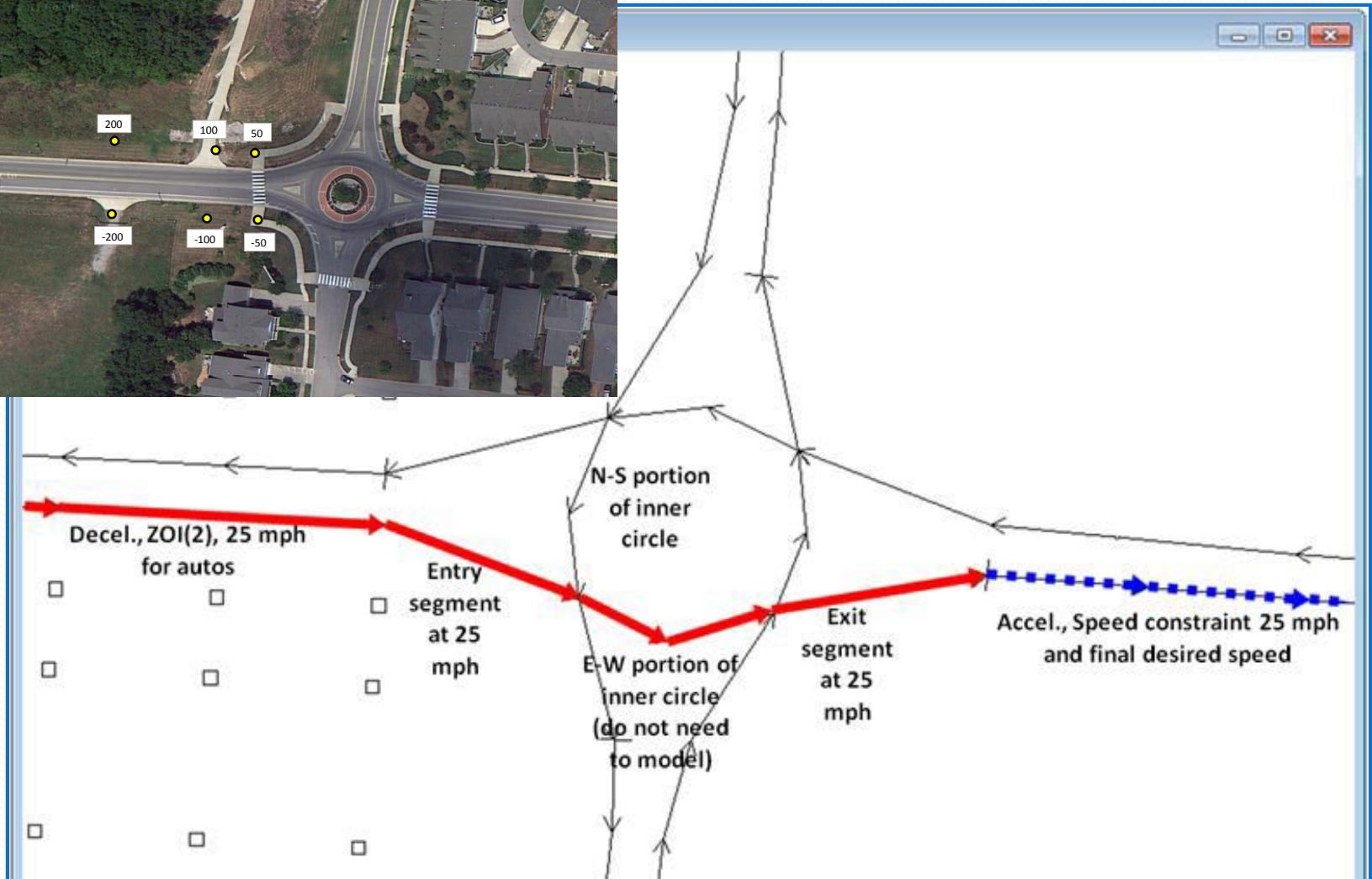 - Departure: flow control roadway with 50% Vehicles Affected and Speed Constraint = 20 mph

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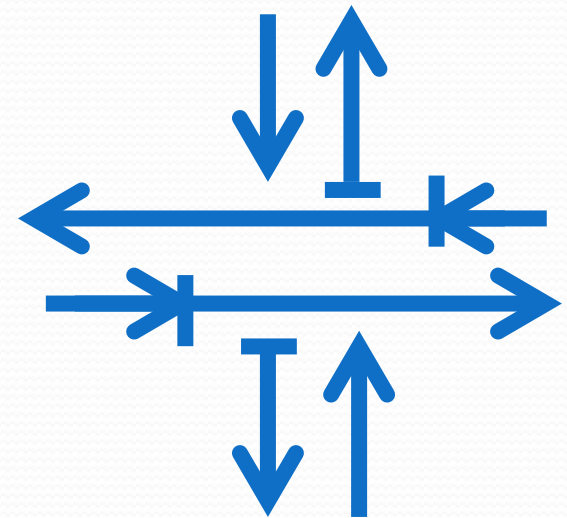
Roundabouts

- "Modern roundabout" as defined in NCHRP Report 672, *Roundabouts: An Informational Guide, 2nd Ed.*

Site Category	Recommended Maximum Theoretical Entry Design Speed
Mini-Roundabout	20 mph (30 km/h)
Single Lane	25 mph (40 km/h)
Multilane	25 to 30 mph (40 to 50 km/h)

Exhibit 6-2 (left) and Exhibits 6-46/ 6-47 (right) from NCHRP Report 672

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Roundabouts - One-lane inner circle

Two-lane inner circulatory road

- Greater circumference
- Slightly higher speed of inner road:
  - 20-25 mph instead of 15-20 mph for smaller one-lane circulatory road
- Yet, model essentially the same as for one-lane inner circulatory road

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Summary

- Pay attention to segment lengths for flow-control acceleration TNM roadways

- Modeling of deceleration is generally not needed because downstream acceleration dominates levels, even at upstream receivers

- Partial modeling of SPUI movements and intersection cross roads eliminates intersecting roads

- Roundabout modeling can be simplified, again because of noise from acceleration on departure legs

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Acknowledgements

- Colleagues who responded to the survey and provided reports and TNM runs

- NCHRP 25-34 Project Panel and Senior Program Officer Lori Sundstrom

- Research team, with Chris Menge of HMMH as PI

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Questions?

Signalized Intersection – One-Way Roadway

- Departure: model as a flow control roadway starting halfway back the upstream queue: 50% Vehicles Affected, Speed Constraint = 0 mph

- Approach: model as a constant-speed roadway ending halfway back in queue. The low speed deceleration does need to be modeled unless the posted speed is high because of the dominance of noise from the percentage of traffic cruising through the signal and the percentage of traffic accelerating from a stopped condition on the upstream side of the intersection

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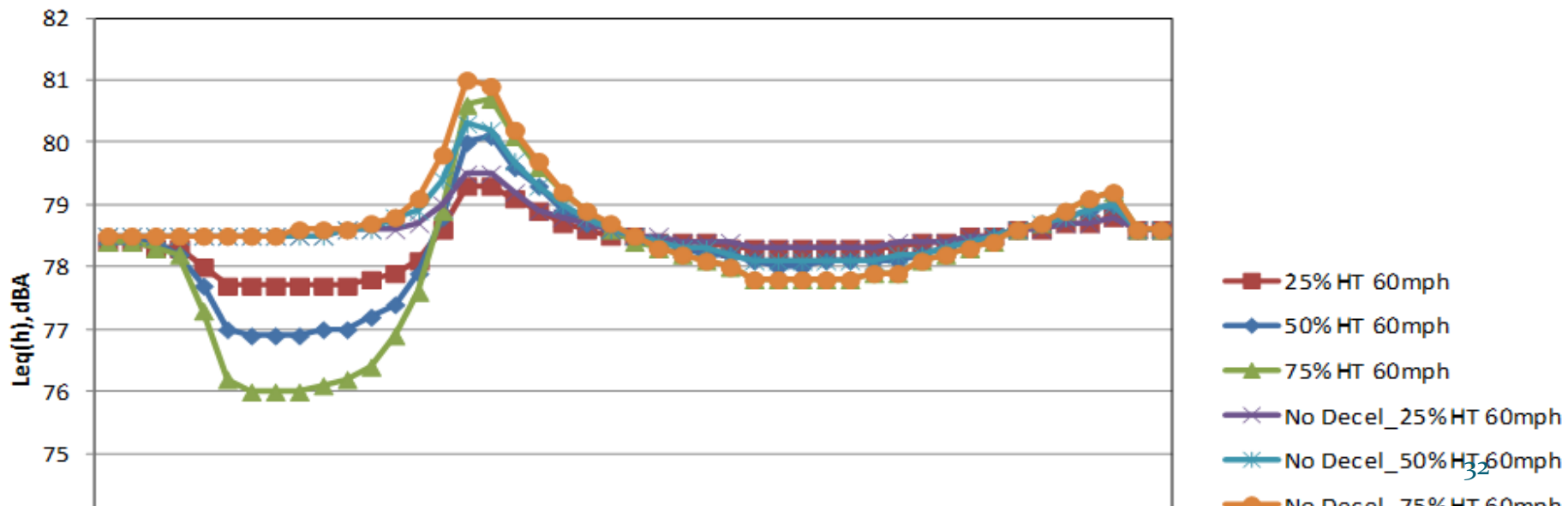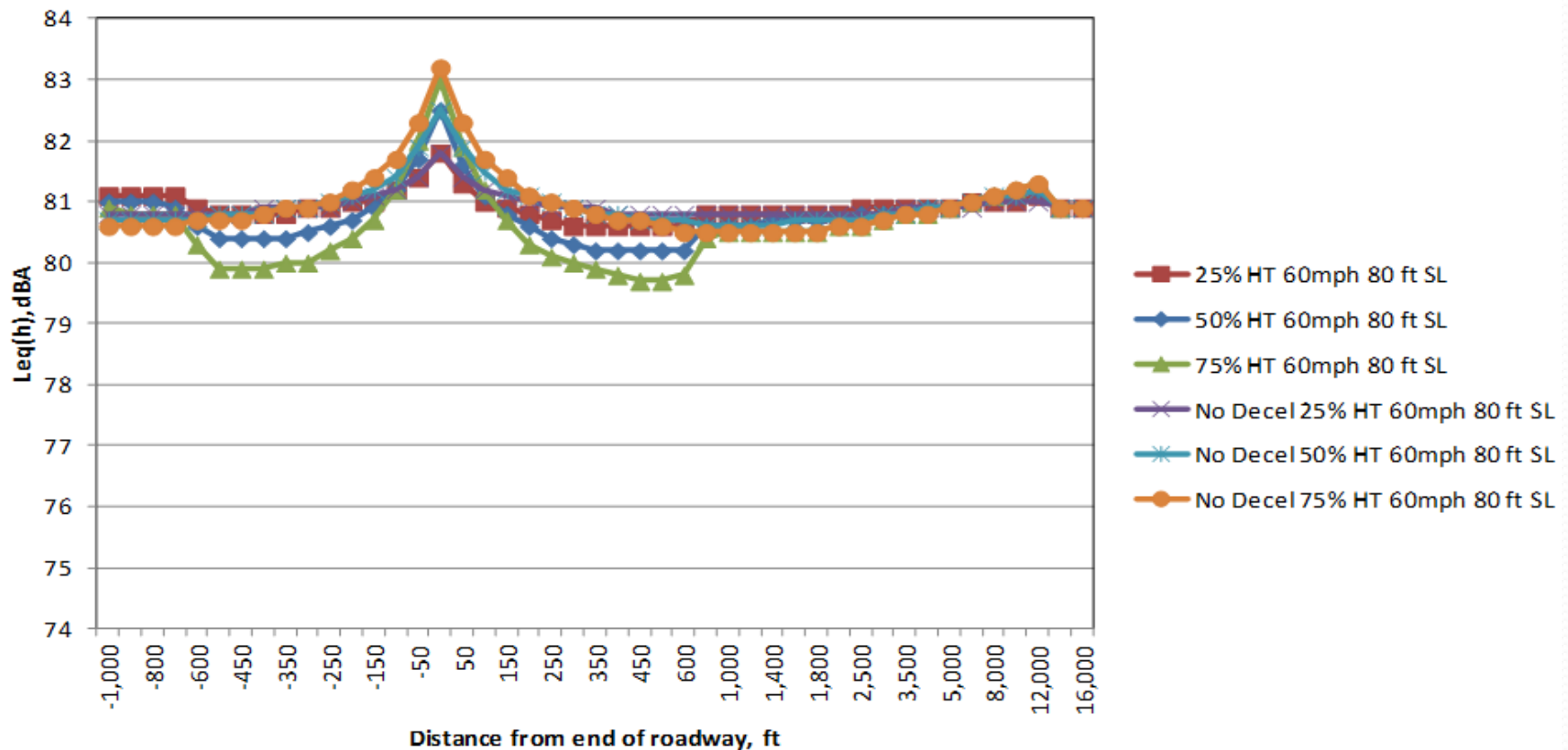# Signalized Intersection – One-Way Roadway – 30 mph

Figure 17 L_{eq}(h) for 1,000 heavy trucks for one-way "Deceleration + Cruise" compared to "All Cruise" on the upstream speed and ar from the roa
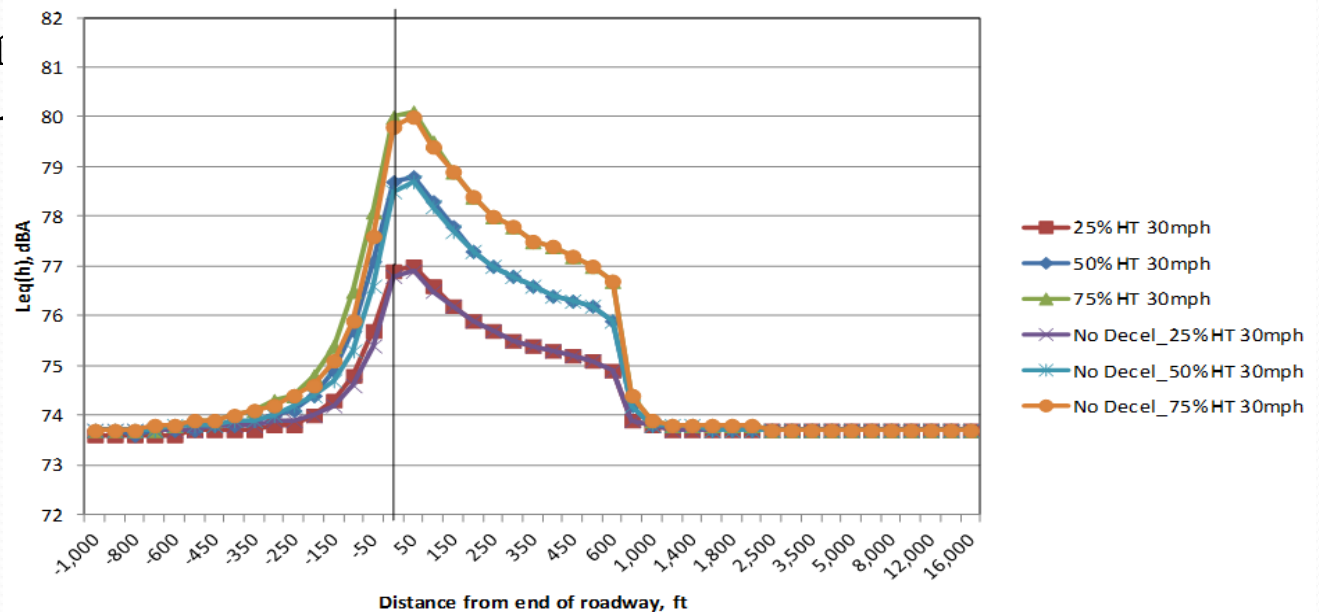
- Figure 18 L_{eq}(h) for 1,000 heavy trucks for one-way "Deceleration + Cruise" compared to "All Cruise" on the upstream deceleration side for a 60 mph cruise speed and an array of receivers at a 50-ft offset distance from the roadway

Signalized Intersection – Two-way roadways

- **Figure 19 L_{eq}(h) for 1,000 heavy trucks for two-way "Deceleration + Cruise" compared to "All Cruise"**

Topics

- Concepts –acceleration and deceleration modeling
- Flow-control roadway segment lengths
- Signalized Interchanges
- Intersections
- Roundabouts

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Liberty Pike roundabout noise measurement site and points

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Entrance ramp roadway length

- **Option 1:** Model roadway past physical merge point and then parallel to and offset by a foot from outer mainline roadway until end of modeled mainline roadway


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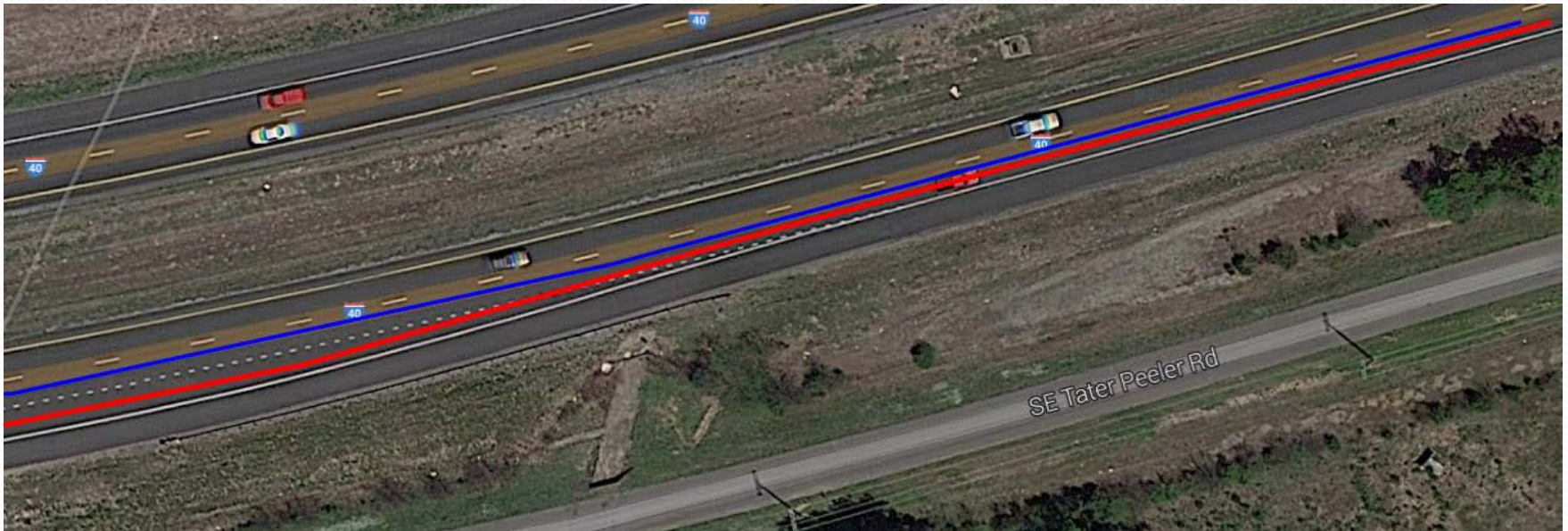
One-lane inner circulatory road

- Approach Leg
  - Constant speed (posted speed) up to beginning of splitter island/crosswalk, and
  - One 25-mph segment for entry leg, ending at entry point to circulatory road.
- Inner circulatory road – Traffic does not need to be modeled
- Departure leg
  - One-segment constant-speed roadway at 25 mph, starting at exit point from circulatory road and ending at near splitter island/crosswalk
  - A flow control roadway to the end of the modeled site (Speed Constraint = 25 mph and 100% Vehicles Affected)

Unsignalized intersection – two-way stop

- Model main road by TNM roadways in each direction at cruise speed - no acceleration or deceleration

- Model cross road:

  - Departure: Flow control roadway : 100% Vehicles Affected and Speed Constraint = 15-20 mph

  - Approach: Posted speed – no modeling of deceleration needed

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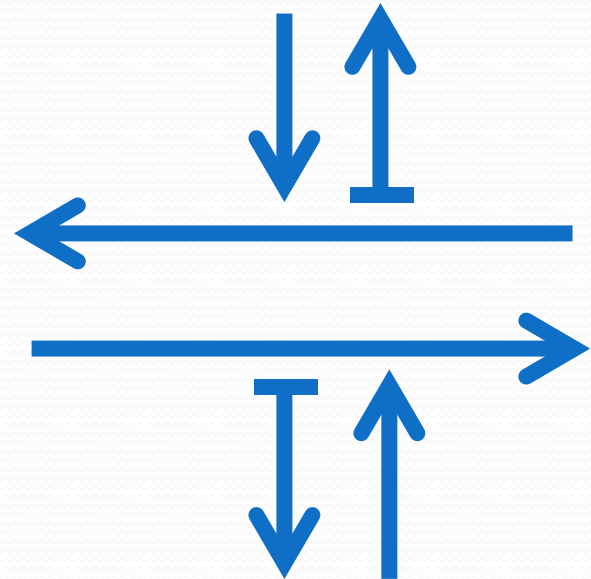
Unsignalized intersection – four-way stop

- Similar to 2-way stop, but with flow control roadway for dominant road starting at stop line: Speed Constraint = 0 mph and 100% Vehicles Affected.

- Cross road: same as 2-way stop unless:

  - Posted speed is high, and
  - The simpler modeling is close to showing impacts