

# Diverging Diamond Interchanges (DDI)

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# Background

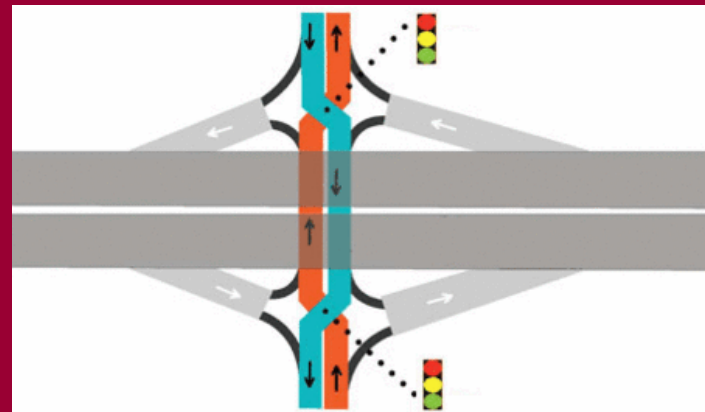
- EOE Corridor study (CH2M Hill)
- Two VISSIM models of DDI
  - I-90 @ Elmhurst
  - EOE @ Roselle
- Share what I learned about DDI

# Outline

- What is a DDI?
- How does it work?
- History
- RWA Project application
- Real world experience
- Major advantages
- Major disadvantages
- Discussion
- Questions?

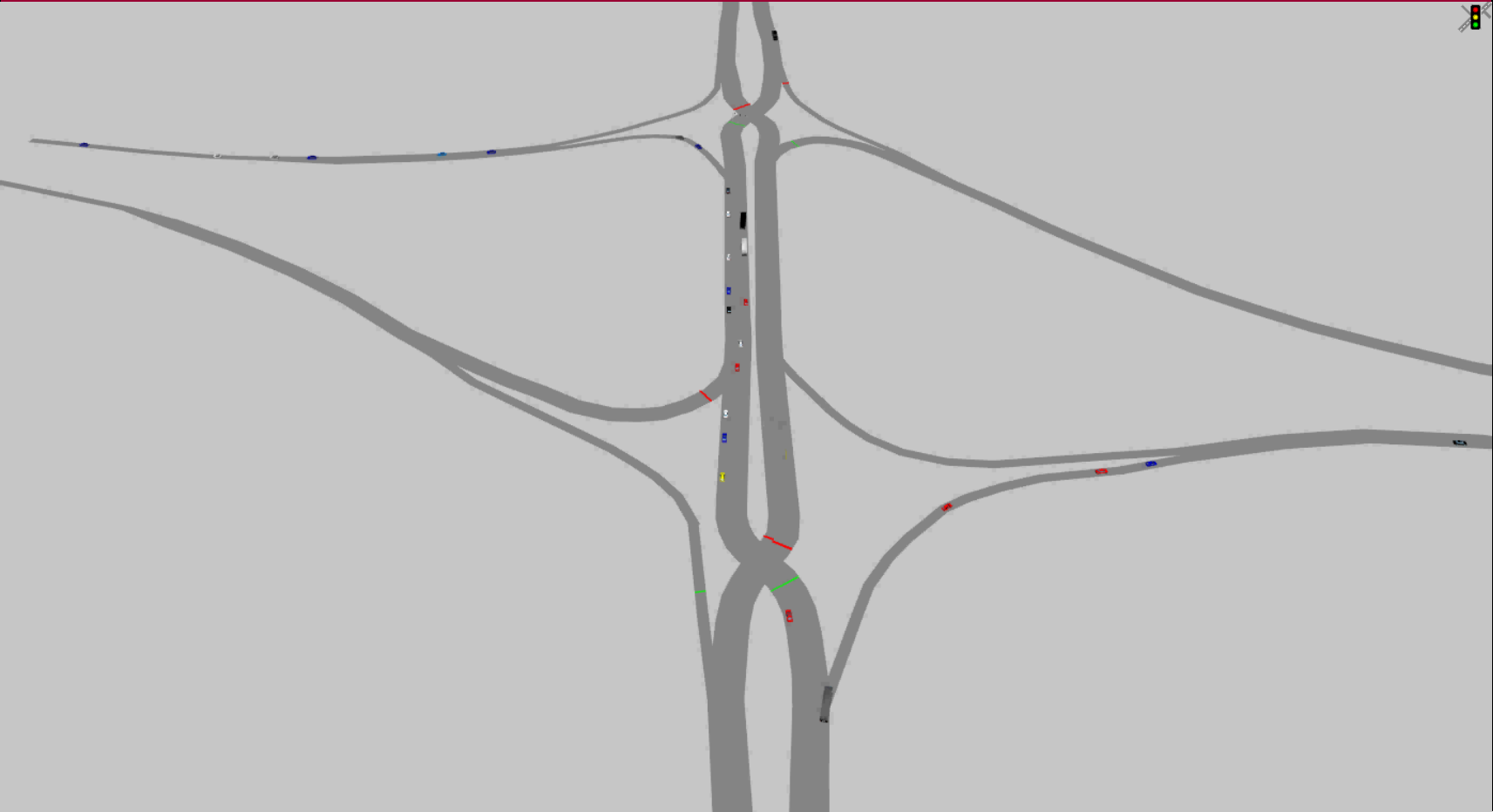
# What is a DDI?

- A new type of freeway and arterial interchange design
- One of the best innovations in 2009 (engineering category) – *Popular Science* magazine
- The two directions of traffic on the non-freeway road cross to the opposite side on both sides of the bridge at the freeway
- Two signals : one at each end of the ramp terminals, no left-turn phasing for arterial road



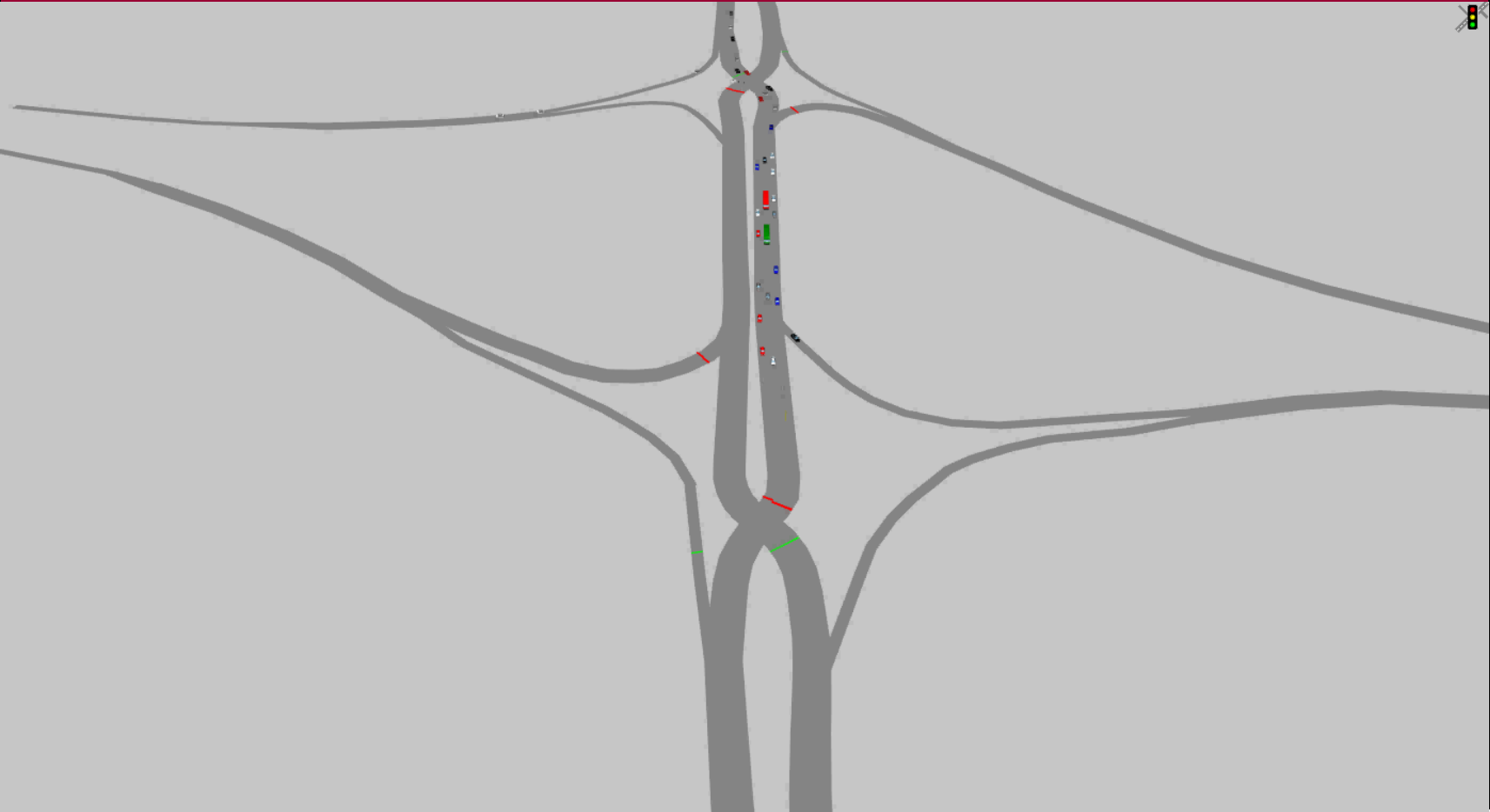
# How does it work?

- [NB traffic](#)



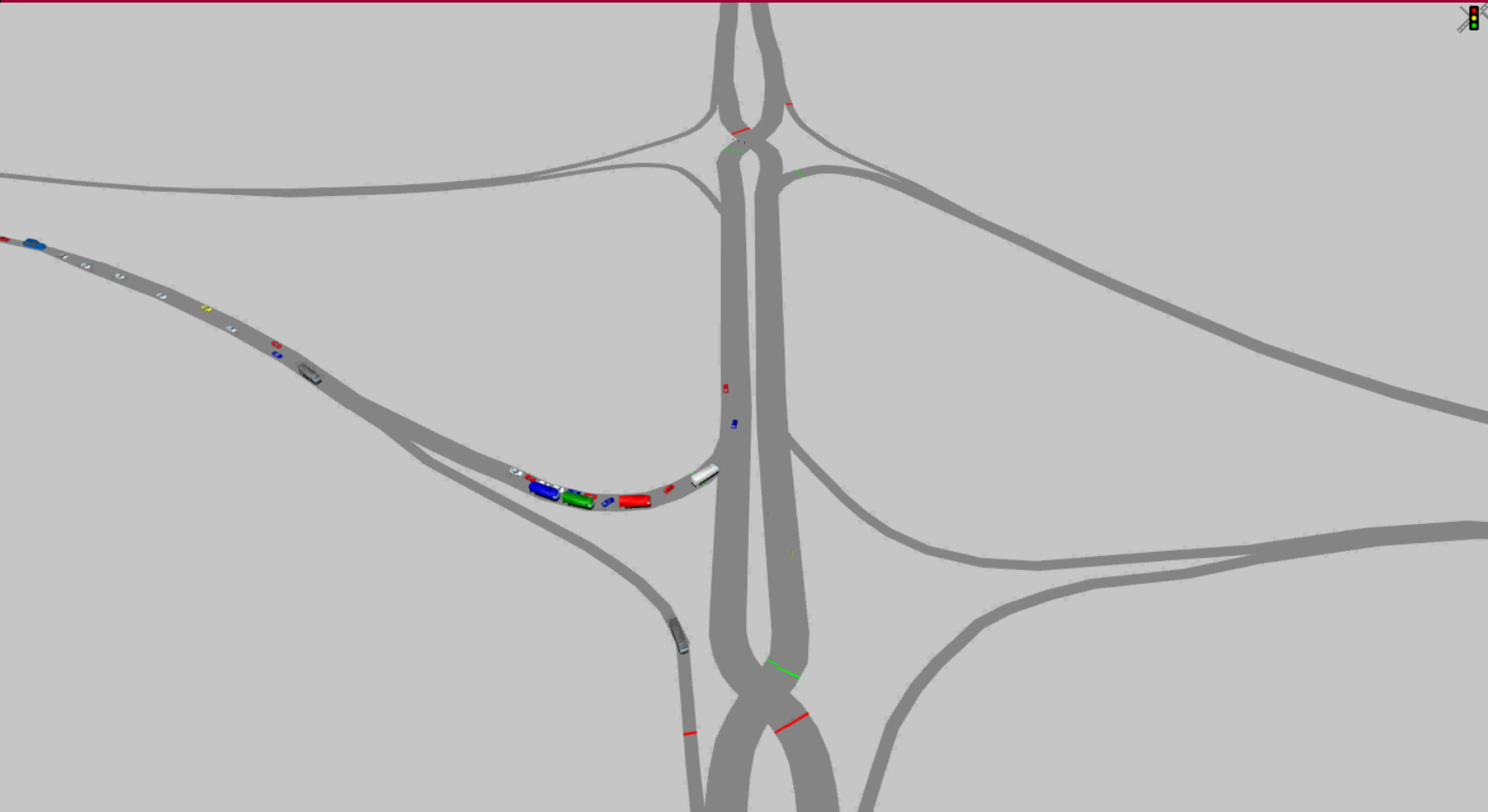
# How does it work?

- [SB traffic](#)



# How does it work?

- [EB traffic](#)



# How does it work?

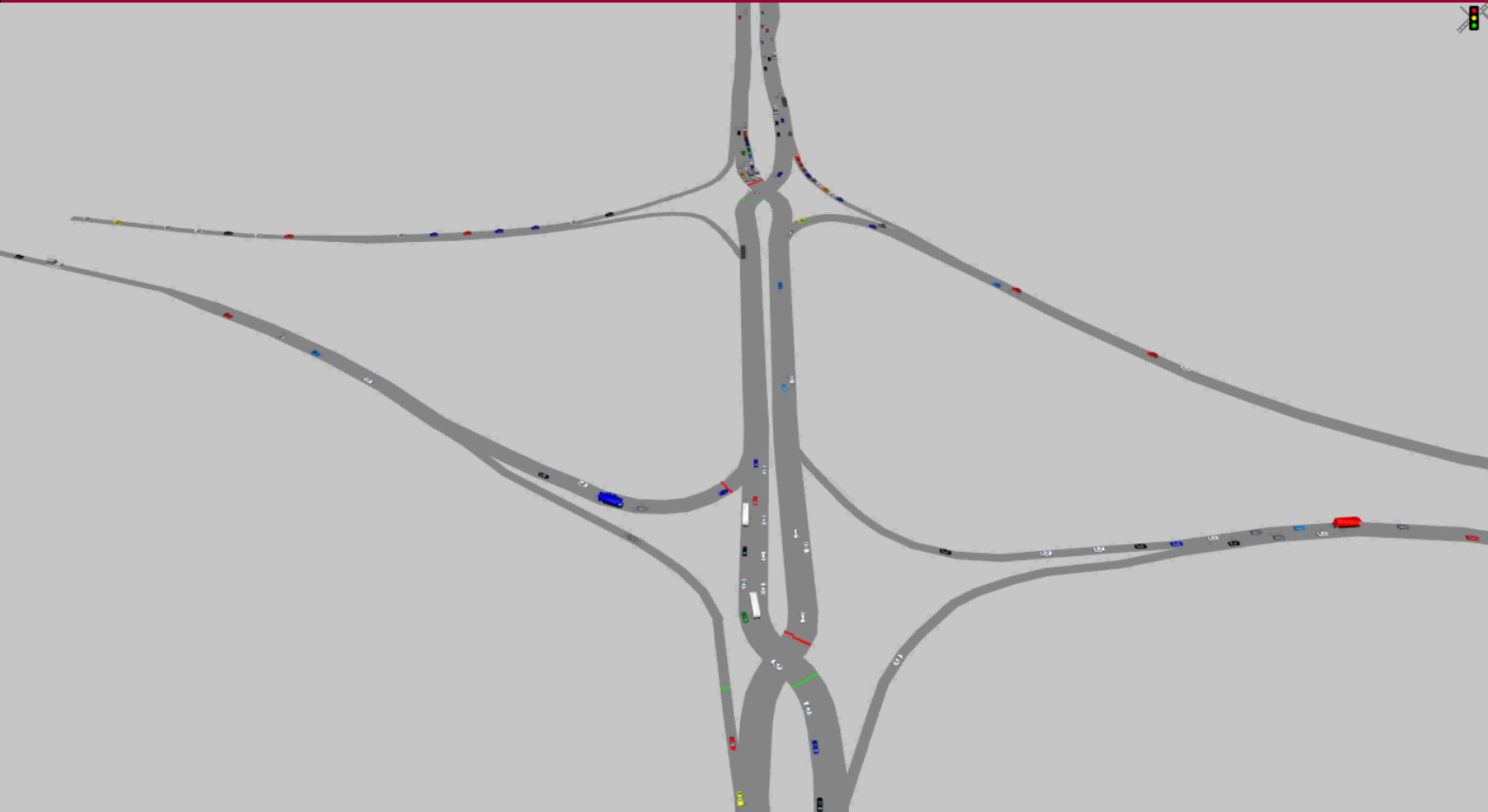
- [WB traffic](#)





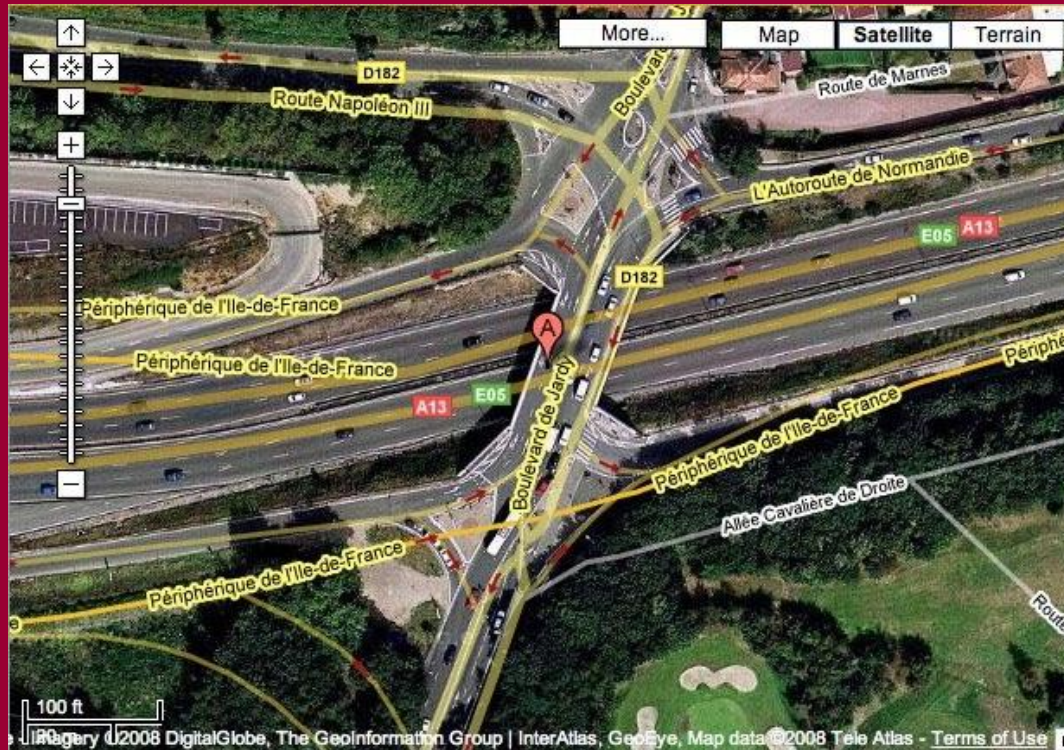
# How does it work?

- All traffic



# History

- Before US built the first DDI, the only known diverging diamond interchanges were located in France in the communities of Versailles, Le Perreux-sur-Marne, and Seclin.



## History (Cont'd)

- July 2003 - Gilbert Chlewicki presented a paper entitled “New Interchange and Intersection Designs: The Synchronized Split-Phasing Intersection and the Diverging Diamond Interchange“, at the 2nd Urban Street Symposium in Anaheim, California.
- January 2005 - J. G. Bared, P. K. Edara, R. Jagannathan presented “Design and Operational Performance of Double Crossover Intersection and Diverging Diamond Interchange”, at the TRB Meeting in Washington, DC.
- The first candidate was I-75 & US 244 in Findlay, Ohio. Due to safety concerns another alternative won over the DDI at the final selection.

## History (Cont'd)

- FHWA studied the safety aspects of the DDI
  - Drivers were intuitively able to maneuver within the DDI and find the paths to their intended destinations
  - The initial concern about wrong way movements at the crossover areas was not warranted
- The Kansas City DDI was anticipated to be completed in 2008 and be the first DDI in the United States – delays prevented it from being constructed. However, due to this interest, FHWA did the human factors research with the Highway Driving Simulator.
  - properly designed DDIs will prove to be considerably safer than properly designed conventional diamond interchanges
- The winner of the first DDI built in the USA is ...

## History (Cont'd)

- I-44 and Kansas Expressway (SR 13), in Springfield, Missouri
  - opened on June 21, 2009
  - became the first DDI in the USA.



## History (Cont'd)

- US 60 James River Freeway and National Avenue – the second diverging diamond interchange to appear in Springfield, Missouri, opened on July 12, 2010.
- I-15 @ American Fork Main Street - American Fork, Utah – opened on August 23, 2010.
- I-270 and Dorsett Road, Maryland Heights, Missouri – opened on October 17, 2010.
- US 129 Bypass / SR 115 @ Middlesettlements Road / Bessemer Street, Alcoa, Tennessee – opened on December 17, 2010.
- IDOT and the City of Naperville are considering a DDI for the I-88 and IL 59 interchange. ( - Chicago Tribune, July, 2010). This could be the first in Illinois.
- More states are considering DDI.

## Project application: I-90 @ Elmhurst

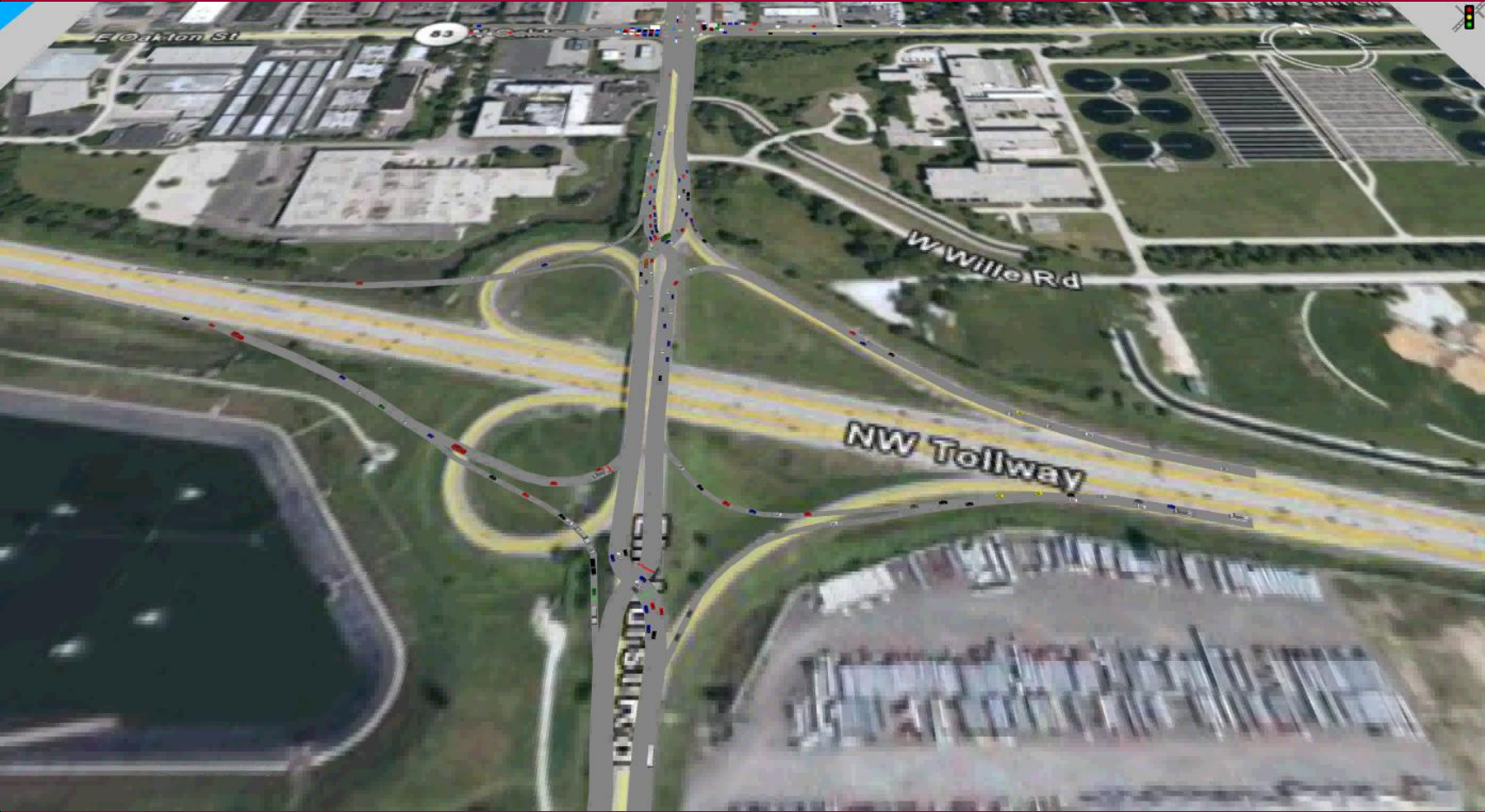
- Compare DDI and Parclo B Single designs
- Modeling Area - Elmhurst Road from north of Landmeier Boulevard to north of Oakton Street with the proposed lane configuration.
- Network Attributes –
  - Speed limits - Elmhurst Road crossing I-90
    - DDI – 30 mph
    - Parclo B – 40 mph
  - Signal timings – Synchro software
  - PM design hour volumes

# I-90 @ Elmhurst – DDI





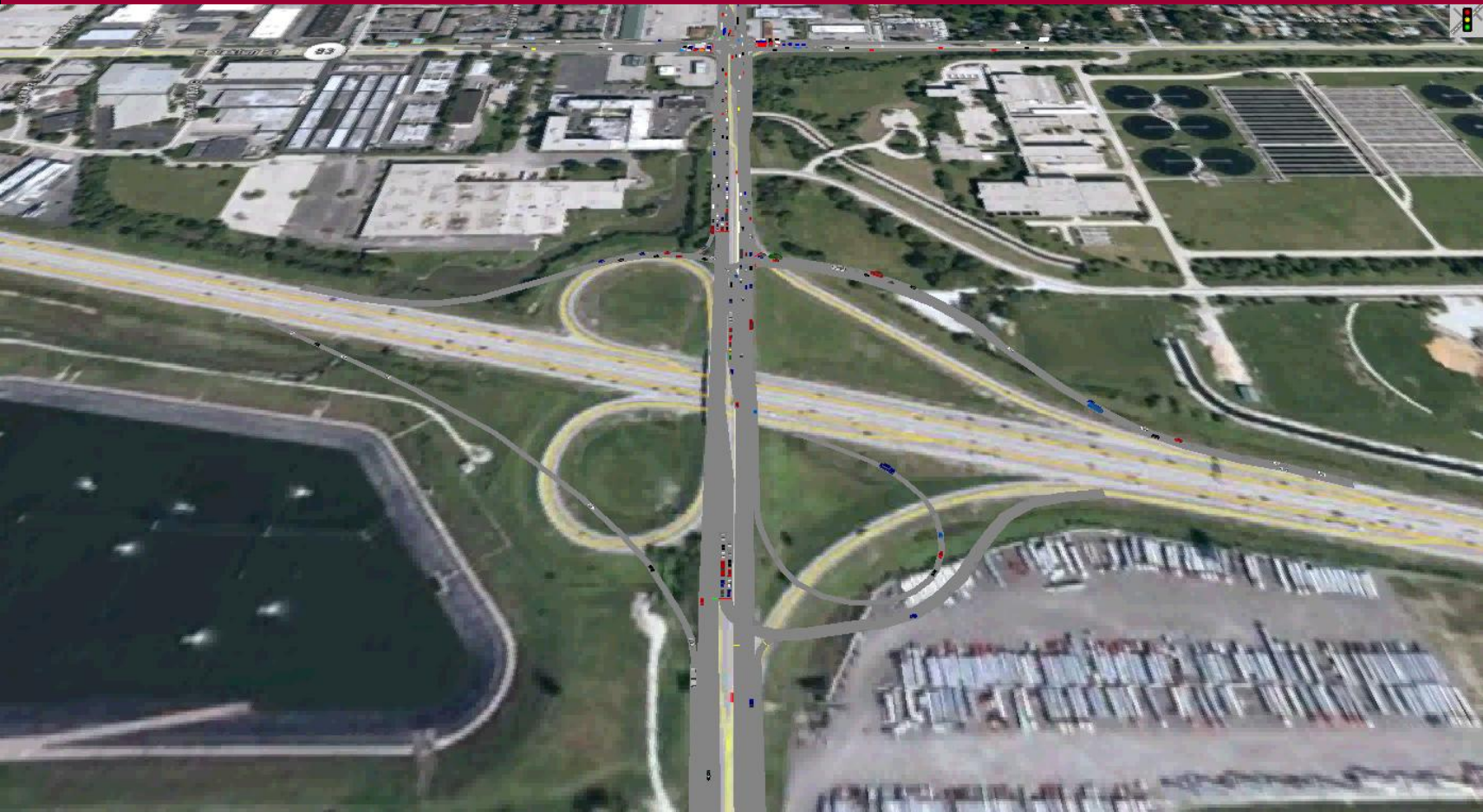
# I-90 @ Elmhurst – DDI



# Simulations – Parclo B Single



# Simulations – Parclo B Single



# I-90 @ Elmhurst – Delay Comparison

Movements		Delay / Vehicle (Sec)		# of Vehicles		Total Delay		Approach Delay		Intersection Delay	
		ParcloB	DDI	ParcloB	DDI	ParcloB	DDI	ParcloB	DDI	ParcloB	DDI
North	WBR	27	20	575	629	15468	12391	29.2	26.1	24.4	16.2
	WBL	31	31	835	810	25718	25191				
	NBL	26	3	611	620	15886	1550	20.3	9.2		
	NBT	14	13	543	1150	7548	14720				
	SBT	29	23	1283	1239	36822	28249	23.4	15.3		
	SBR	14	2	690	719	9315	1654				
South	EBL	2	29	567	576	907	16646	1.5	20.3	11.7	15.1
	EBR	1	13	665	656	931	8397				
	NBT	17	10	1156	1203	20114	11669	19.2	6.8		
	NBR	23	1	623	595	14018	536				
	SBL	30	6	678	693	20204	3812	11.2	19.8		
	SBT	0	28	1173	1164	469	32941				



# Real world experience: I-44 & SRI3

- Issues:
  - Congestion
  - Left-turn traffic backing up and blocking through traffic
  - Majority of crashes were rear-end crashes and left-turn right angle crashes
  - Limited funds
- Reasons to choose DDI
  - Utilizes most of the existing structure including the bridge
  - Cheaper than SPUI (Single Point Urban Interchange):
    - \$3.2 million vs. \$10 million
  - Quicker to build: it took about 6 months
  - Safer
  - Pedestrian walk way in the center

# Real world experience: I-44 & SRI3

- Statistics (first 6 months after the DDI opened)
  - 50% overall reduction of crashes
  - Right angle crashes eliminated (previously 33%)
  - Rear-end crashes reduced (previously 40%)
- Public perception survey
  - Mailed out 400 random surveys
  - 75 respondents (20% return)
  - Results
    - ✓ 96.7% - Safer
    - ✓ 95.1% - More convenient
    - ✓ 95.2% - Less congested
    - ✓ 86.9% - Easier to drive
    - ✓ 89.4% - Right transportation solution
- FHWA will evaluate operations 2 years after completion

# Major advantages

- Safety
  - Eliminates the conflict of left turns and oncoming traffic, better accommodates left turn movements
  - Fewer conflict points
- Cost
  - Less than traditional diamond
- Travel Time
  - No turning phases are required
  - Shorter cycle length, less lost time, yellow and all red time
- Geometry
  - Reduce bridge size & ROW requirements
- Alleviates congestion

## Major disadvantages

- Drivers' unfamiliarity
- No free-flowing traffic in both directions (unlike Parclo)
- Off-ramp traffic can not re-enter the freeway when drivers mistakenly exit at the wrong interchange (problems with maintenance)
- Crossing over usually requires more space
- May not suit the situation where a cross road's adjacent intersection is closely located with heavy traffic



# Discussion

- No one design fits all
- How to compare
  - What are the major constraints (ROW, bridge/underpass, cost)
  - What are the characteristics of the traffic
    - (balanced vs. unbalanced traffic, turning movement volumes)
  - What are the costs and benefits under the same constraints (# of lanes, budget, LOS, ...)
- How to improve DDI design
  - Signal design
  - Signage, pavement marking, lighting
  - Number of lanes needed

## Discussion (Cont'd)

- When to consider DDI
  - One of the left turning movements is high
  - and/or if thru movements are unbalanced during peak hours
  - Structure widening costs should be minimized
- If you have driven one please let us know how you like it

Questions?