

To:	Wade Frank, PE Stantec Project Manager	From:	Adam Capets, PE, PTOE Transportation Engineer
Project/File:	193806354 - Moorhead I-94/20th Street Interchange Analysis	Date:	September 11, 2024

Reference: Highway Interchange Tool (HIT) Results

Highway Interchange Tool (HIT)

The Highway Interchange Tool (HIT) is a proprietary tool developed by Stantec to investigate feasible interchange layouts based on a series of volume, geometric, and area characteristics inputs. The HIT examines several dozen unique interchange layouts with many variations for each layout. The HIT delivers a final score for each layout based on three categories: operational efficiency, safety, and cost.

Inputs and Outputs

The volume inputs used in the HIT for this analysis were the 2050 peak hour volumes for the freeway and ramp terminal intersections developed under the Travel Demand Modeling task, with separate HIT analyses being conducted for the AM and PM peak hours. The HIT analysis assumed a full access interchange would be constructed, and thus movements for an eastbound on-ramp and westbound off-ramp were included in the 2050 volumes. Pedestrian and bicycle volumes were also included, assuming conservative volumes of 20 each per hour per direction to ensure the HIT accounted for active transportation.

The geometric and area characteristics inputs included many aspects of the interchange including lane, ramp, and taper geometry, speeds, terrain, area population, adjacent interchange spacing, signal timing parameters, right-of-way, and construction costs. While the HIT is most suitable for interchanges that can utilize all quadrants, to best account for the railroad on the east side of 20th Street as a geometric constraint, the tool was set to assume right-of-way is cost-prohibitive in the northeast and southeast quadrants. The HIT inputs are provided as an attachment to this memo.

Results and Conclusions

The HIT was conducted independently for AM and PM peak hour volumes, however most of the interchange layouts that resulted from the analyses were the same between both peak hours. The roughly top 20 scoring layouts for each peak hour were selected and their AM and PM scores were summed and ordered from highest to lowest into an aggregate list of top alternatives. The results included some duplicate interchange layouts, thus they were excluded from the final list. This list of top alternatives and their respective aggregate scores are shown in the table below. The HIT outputs of the top alternatives and schematic diagrams of each layout are provided as an attachment to this memo.

Reference: Interchange Evaluation Tool Results

Top Alternatives for Interchange Layouts	
Interchange Layout Name	AM & PM Total Score
1. Diverging Diamond Interchange (DDI)	13.1
2. Diamond with U-turn for Arterial Lefts	12.6
3. Diamond with U-turn over Freeway and Slip Lanes for Arterial Lefts	12.5
4. Single Quadrant	12.0
5. Diamond Single Point with Displaced Ramp Lefts	11.9
6. Diamond Single Point/Single Point Urban Interchange (SPUI)	11.8
7. Diamond with U-turn for Arterial and Ramp Lefts	11.8
8. Diamond with Contraflow Arterial Lefts and U-turn for Ramp Lefts	11.6
9. Elevated Double U-turn	11.6
10. Standard Diamond	11.6
11. Diamond Single Point with Displaced Arterial Lefts	11.3
12. Half Clover/Parclo	11.3
13. Diamond Single Point with U-turn for Arterial Lefts	10.8
14. Diamond with Displaced Arterial Lefts and U-turn for Ramp Lefts	10.8
15. Diamond with Displaced Arterial Lefts	10.7

Due to the existing constraints involving the railroad to the east of 20th Street, some of the alternatives resulting from the HIT analysis are less feasible than others. Many of the alternatives require utilizing all quadrants, which would require additional grade separation from the railroad and thus increased structure costs for 20th Street. Roadway and structure width on 20th Street should be minimized to keep structure costs as low as possible. Interchange layouts involving single point intersections, displaced lefts, or contraflow lefts require additional width on 20th Street to accommodate the geometry, and thus should be avoided. This includes Alternatives 5, 6, 8, 11, 13, 14, and 15. While the DDI also may require additional roadway and structural width, since it results in the highest score, it was not excluded.

The following interchange layout alternatives resulting from the HIT should be advanced for further consideration and compared alongside previously identified interchange alternatives:

1. Diverging Diamond Interchange (DDI)
2. Diamond with U-turn for Arterial Lefts
3. Diamond with U-turn over Freeway and Slip Lanes for Arterial Lefts
4. Single Quadrant
7. Diamond with U-turn for Arterial and Ramp Lefts
9. Elevated Double U-turn
10. Standard Diamond
12. Half Clover/Parclo

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Reference: Interchange Evaluation Tool Results

Regards,

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Attachment: HIT Inputs, HIT Output and Top Alternatives

AM

PM

Freeway Direction
East/West

Southbound Through

	Bikes	Pedestrians
Volume	20	20
PHF	0.85	0.85

Southbound Arterial

Truck %	2%	2%	2%
PHF	0.85	0.85	0.85
Volume	264	170	66

Eastbound Freeway

Truck %	PHF	Volume
2%	0.85	284
16%	0.85	2,544
2%	0.85	264

Left

Through

Right



Right

Through

Left

Westbound Freeway

Volume	PHF	Truck %
82	0.85	2%
3,055	0.85	16%
202	0.85	2%

Left Through Right

Volume	413	445	159
PHF	0.85	0.85	0.85
Truck %	2%	2%	2%

Northbound Arterial

PHF	0.85	0.85
Volume	20	20
	Bikes	Pedestrians

Northbound Through

Freeway Direction
East/West

Southbound Through

	Bikes	Pedestrians
Volume	20	20
PHF	0.91	0.91

Southbound Arterial

Truck %	2%	2%	2%
PHF	0.91	0.91	0.91
Volume	316	374	94

Eastbound Freeway

Truck %	PHF	Volume
2%	0.91	335
16%	0.91	2,971
2%	0.91	538

Left

Through

Right



Right

Through

Left

Westbound Freeway

Volume	PHF	Truck %
84	0.91	2%
2,728	0.91	16%
143	0.91	2%

Left Through Right

Volume	374	244	224
PHF	0.91	0.91	0.91
Truck %	2%	2%	2%

Northbound Arterial

PHF	0.91	0.91
Volume	20	20
	Bikes	Pedestrians

Northbound Through

Required Inputs

Roadway Geometry

Freeway # of Lanes (EB):	2
Freeway # of Lanes (WB):	2
Freeway Lane Width (ft):	12
Freeway Inside Paved Shoulder Width (ft):	4
Freeway Outside Paved Shoulder Width (ft):	10
Acceleration Lane Length (ft):	800
Second Acc. Lane Additional Length (ft):	800
Deceleration Lane Length (ft):	400

Ramp Left Paved Shoulder Width (ft):	4
Ramp Right Paved Shoulder Width (ft):	4
C-D Left Paved Shoulder Width (ft):	4
C-D Right Paved Shoulder Width (ft):	4

Arterial # of Lanes (NB):	2
Arterial # of Lanes (SB):	2
Arterial Lane Width (ft):	12
Arterial Median Type:	Undivided
Arterial Inside Paved Shoulder Width (ft):	0
Arterial Outside Paved Shoulder Width (ft):	0

Facility Free Flow Speeds

Freeway Speed (mph):	55
Arterial Speed (mph):	30
Left Over Speed (mph):	30
Ramp Speed (mph):	35
Loop Speed (mph):	25
Flyover Speed (mph):	45
Freeway Flyover U-Turn Speed (mph):	30
C-D Speed (mph):	45

Driver Population Adjustments

Freeway Capacity Adjustment Factor:	1.00
Freeway Speed Adjustment Factor:	1.00
Average Vehicle Occupancy:	1.64

Area Characteristics

Terrain:	Level
Metropolitan Area with Population ≥ 250k:	TRUE
Location in Central Business District:	FALSE
Interchange Density (interchange/mile):	1.053

Signal Timing Settings

Critical Intersection Volume-to-Capacity Ratio:	0.85
Platoon Ratio:	1.00

Minimum Cycle Length - 2 phase (s):	45
Minimum Cycle Length - 3 phase (s):	60
Minimum Cycle Length - 4+ phase (s):	75
Maximum Cycle Length (s):	180
Minimum Green Time - Major Movement (s):	15
Minimum Green Time - Minor Movement (s):	5
Yellow Time (s):	3.5
Red Time (s):	2.0
Start-Up Lost Time (s):	1.0
Extension of Effective Green (s):	1.0
Volume Requiring Dual Left Turn Lanes (vph):	300
Maximum Delay Override (s):	300

Measure of Effectiveness Weights

Efficiency Weight:	1.00
Cost Weight:	1.00
Safety Weight:	1.00

Measure of Effectiveness Range

Minimum MOE Score:	0
Maximum MOE Score:	10

Right-of-Way Availability

Available NE Quadrant ROW (sqft):	Tight
Available NW Quadrant ROW (sqft):	Tight
Available SW Quadrant ROW (sqft):	Standard
Available SE Quadrant ROW (sqft):	Standard

Cost of NE Quadrant ROW (\$/sqft):	Prohibitive
Cost of NW Quadrant ROW (\$/sqft):	\$ 0.65
Cost of SW Quadrant ROW (\$/sqft):	\$ 0.65
Cost of SE Quadrant ROW (\$/sqft):	Prohibitive

Infrastructure Costs

Cost for Sq. Yard of Pavement (\$):	\$ 42
Cost for Sq. Yard of Bridge (\$):	\$ 1,500
Cost for Signalization (\$):	\$ 230,000

Weights for Safety Conflict Opportunities

Vehicle Merge:	1.00
Vehicle Diverge:	1.00
Vehicle Crossing:	2.00

Bike Merge:	0.00
Bike Diverge:	0.00
Bike Crossing:	1.00

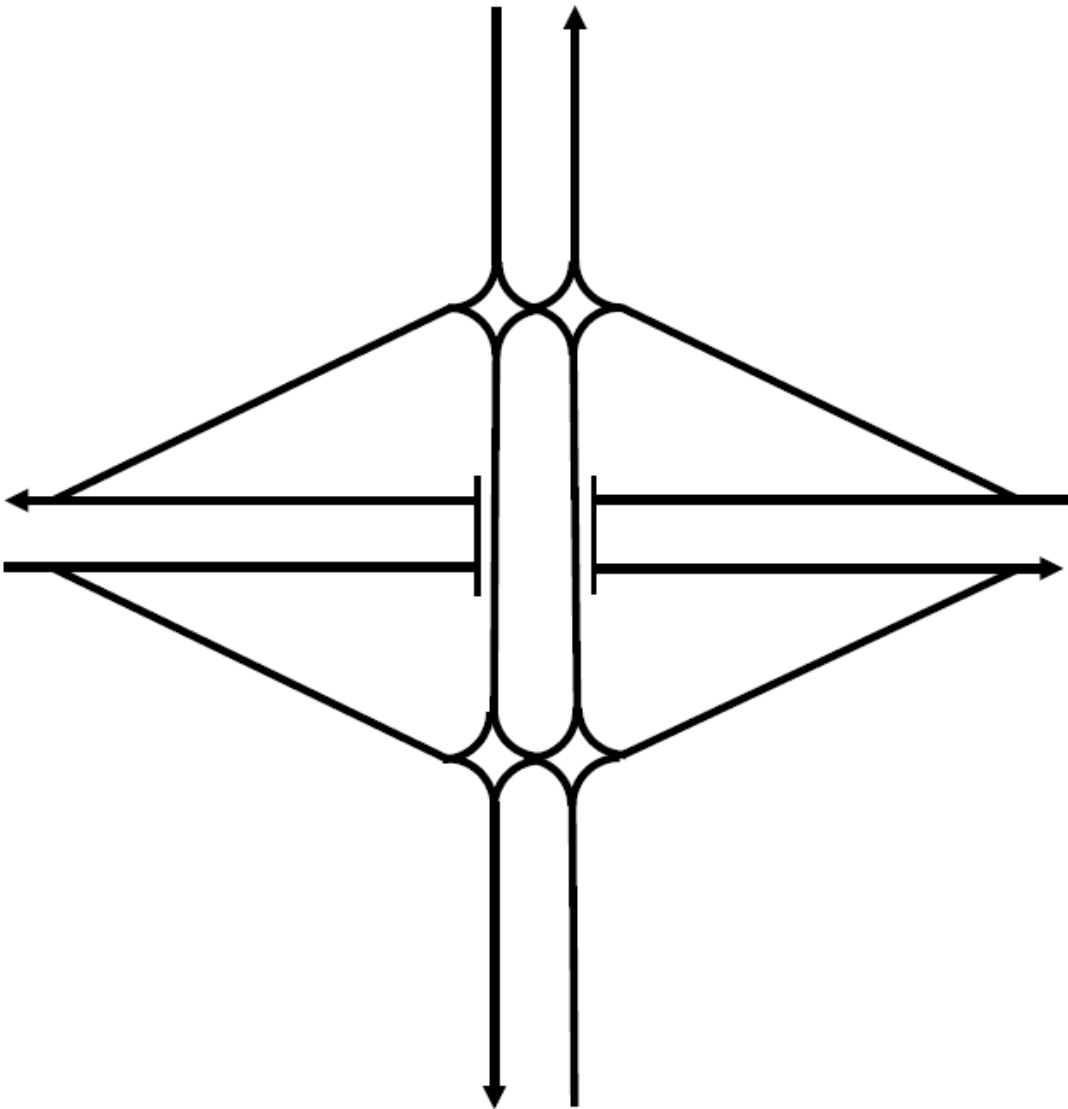
Pedestrian Signal Crossing:	1.00
Pedestrian Stop Crossing:	0.00
Pedestrian Uncontrolled Crossing:	3.00

Sheet	Left from Arterial	Left from Freeway	Name	Avoid ROW?	Base Efficiency	Base Cost	Base Safety	Weighted Efficiency	Weighted Cost	Weighted Safety	Overall Score
AM											
8E.1	8	E	DDI (Tight)	YES	7.6	9.8	2.4	2.5	3.3	0.8	6.6
10B.1	10	B	U Turn on Arterial Tight Diamond (Tight Standard)		5.3	9.3	4.2	1.8	3.1	1.4	6.3
12B	12	B	U Turn over Freeway with Slips Tight Diamond (Tight)	YES	8.0	2.7	8.0	2.7	0.9	2.7	6.3
12B.1	12	B	U Turn over Freeway with Slips Tight Diamond (Standard)		8.1	2.4	8.0	2.7	0.8	2.7	6.2
10B	10	B	U Turn on Arterial Tight Diamond (Tight)	YES	4.5	9.5	4.2	1.5	3.2	1.4	6.1
1E.5	1	E	Displaced Single Point (Tight Standard)		8.8	2.4	7.1	2.9	0.8	2.4	6.1
10G.2	10	G	Ramp Arterial U-Turn (Tight Standard)		1.3	9.4	7.5	0.4	3.1	2.5	6.1
10G.1	10	G	Ramp Arterial U-Turn (Tight)	YES	0.9	9.6	7.5	0.3	3.2	2.5	6.0
2A	2	A	Tight Diamond Single Point (Tight)	YES	8.0	5.0	5.0	2.7	1.7	1.7	6.0
99DF	9		Single Quadrant SE		1.3	6.5	10.0	0.4	2.2	3.3	5.9
11H.3	11	H	Elevated Double U from Dunlop South of Arterial (Standard)		4.5	4.8	8.5	1.5	1.6	2.8	5.9
8A.1	8	A	Displaced Single Point (Tight)	YES	10.0	3.4	4.1	3.3	1.1	1.4	5.8
94DF			Southern Half Clover		2.3	10.0	5.2	0.8	3.3	1.7	5.8
5G	5	G	Tight Contraflow U on Arterial (Tight)	YES	5.3	5.1	6.9	1.8	1.7	2.3	5.8
2B	2	B	Tight Diamond	YES	6.0	7.6	3.6	2.0	2.5	1.2	5.7
94FF		F	Single Quadrant SW		0.7	6.5	10.0	0.2	2.2	3.3	5.7
11H.4	11	H	Elevated Double U from Dunlop South of Arterial (Spread)		3.2	5.1	8.5	1.1	1.7	2.8	5.6
6G.1	6	G	Standard Contraflow U Turn on Arterial (Tight Standard)		5.0	4.7	6.9	1.7	1.6	2.3	5.5
12B.2	12	B	U Turn over Freeway with Slips Tight Diamond (Spread)		8.3	0.0	8.0	2.8	0.0	2.7	5.4
8B.1	8	B	Displaced Tight Diamond (Tight)	YES	6.4	5.0	4.8	2.1	1.7	1.6	5.4
10A.4	10	A	U Turn on Arterial Single Point (Tight Standard)		4.9	6.3	4.9	1.6	2.1	1.6	5.4
PM											
8E.1	8	E	DDI (Tight)	YES	7.4	9.7	2.3	2.5	3.2	0.8	6.5
10B.1	10	B	U Turn on Arterial Tight Diamond (Tight Standard)		5.5	9.3	4.2	1.8	3.1	1.4	6.4
12B	12	B	U Turn over Freeway with Slips Tight Diamond (Tight)	YES	8.0	2.6	8.2	2.7	0.9	2.7	6.3
10B	10	B	U Turn on Arterial Tight Diamond (Tight)	YES	4.9	9.5	4.2	1.6	3.2	1.4	6.2
12B.1	12	B	U Turn over Freeway with Slips Tight Diamond (Standard)		8.1	2.3	8.2	2.7	0.8	2.7	6.2
99DF	9		Single Quadrant SE		1.8	6.5	10.0	0.6	2.2	3.3	6.1
5G	5	G	Tight Contraflow U on Arterial (Tight)	YES	5.6	5.0	6.9	1.9	1.7	2.3	5.9
2B	2	B	Tight Diamond	YES	6.1	7.6	3.8	2.0	2.5	1.3	5.9
2A	2	A	Tight Diamond Single Point (Tight)	YES	7.5	4.9	5.2	2.5	1.6	1.7	5.8
1E.5	1	E	Displaced Single Point (Tight Standard)		8.0	2.3	7.1	2.7	0.8	2.4	5.8
10G.1	10	G	Ramp Arterial U-Turn (Tight)	YES	0.0	9.6	7.7	0.0	3.2	2.6	5.8
11H.3	11	H	Elevated Double U from Dunlop South of Arterial (Standard)		3.5	5.8	7.8	1.2	1.9	2.6	5.7
10G.2	10	G	Ramp Arterial U-Turn (Tight Standard)		0.0	9.4	7.7	0.0	3.1	2.6	5.7
6G.1	6	G	Standard Contraflow U Turn on Arterial (Tight Standard)		5.5	4.6	6.9	1.8	1.5	2.3	5.7
8A.1	8	A	Displaced Single Point (Tight)	YES	9.2	3.3	4.0	3.1	1.1	1.3	5.5
94FF		F	Single Quadrant SW		0.0	6.5	10.0	0.0	2.2	3.3	5.5
8G.1	8	G	Displaced U Turn on Arterial (Tight)	YES	7.0	5.0	4.4	2.3	1.7	1.5	5.5
12B.2	12	B	U Turn over Freeway with Slips Tight Diamond (Spread)		8.3	0.0	8.2	2.8	0.0	2.7	5.5
94DF			Southern Half Clover		2.3	10.0	4.1	0.8	3.3	1.4	5.5
10A.4	10	A	U Turn on Arterial Single Point (Tight Standard)		5.2	6.2	4.9	1.7	2.1	1.6	5.5

Sheet	Left from Arterial	Left from Freeway	Name	Avoid ROW?	AM & PM Total Score
8E.1	8	E	DDI (Tight)	YES	13.1
10B.1	10	B	U Turn on Arterial Tight Diamond (Tight Standard)		12.6
12B	12	B	U Turn over Freeway with Slips Tight Diamond (Tight)	YES	12.5
12B.1	12	B	U Turn over Freeway with Slips Tight Diamond (Standard)		12.4
10B	10	B	U Turn on Arterial Tight Diamond (Tight)	YES	12.3
99DF	9		Single Quadrant SE		12.0
1E.5	1	E	Displaced Single Point (Tight Standard)		11.9
2A	2	A	Tight Diamond Single Point (Tight)	YES	11.8
10G.1	10	G	Ramp Arterial U-Turn (Tight)	YES	11.8
10G.2	10	G	Ramp Arterial U-Turn (Tight Standard)		11.7
5G	5	G	Tight Contraflow U on Arterial (Tight)	YES	11.6
11H.3	11	H	Elevated Double U from Dunlop South of Arterial (Standard)		11.6
2B	2	B	Tight Diamond	YES	11.6
8A.1	8	A	Displaced Single Point (Tight)	YES	11.3
94DF			Southern Half Clover		11.3
94FF		F	Single Quadrant SW		11.2
6G.1	6	G	Standard Contraflow U Turn on Arterial (Tight Standard)		11.2
12B.2	12	B	U Turn over Freeway with Slips Tight Diamond (Spread)		10.9
10A.4	10	A	U Turn on Arterial Single Point (Tight Standard)		10.8
8G.1	8	G	Displaced U Turn on Arterial (Tight)	YES	10.8
11H.4	11	H	Elevated Double U from Dunlop South of Arterial (Spread)		10.7
8B.1	8	B	Displaced Tight Diamond (Tight)	YES	10.7

*This list contains some duplicates with slight variations

1. Diverging Diamond Interchange (DDI)



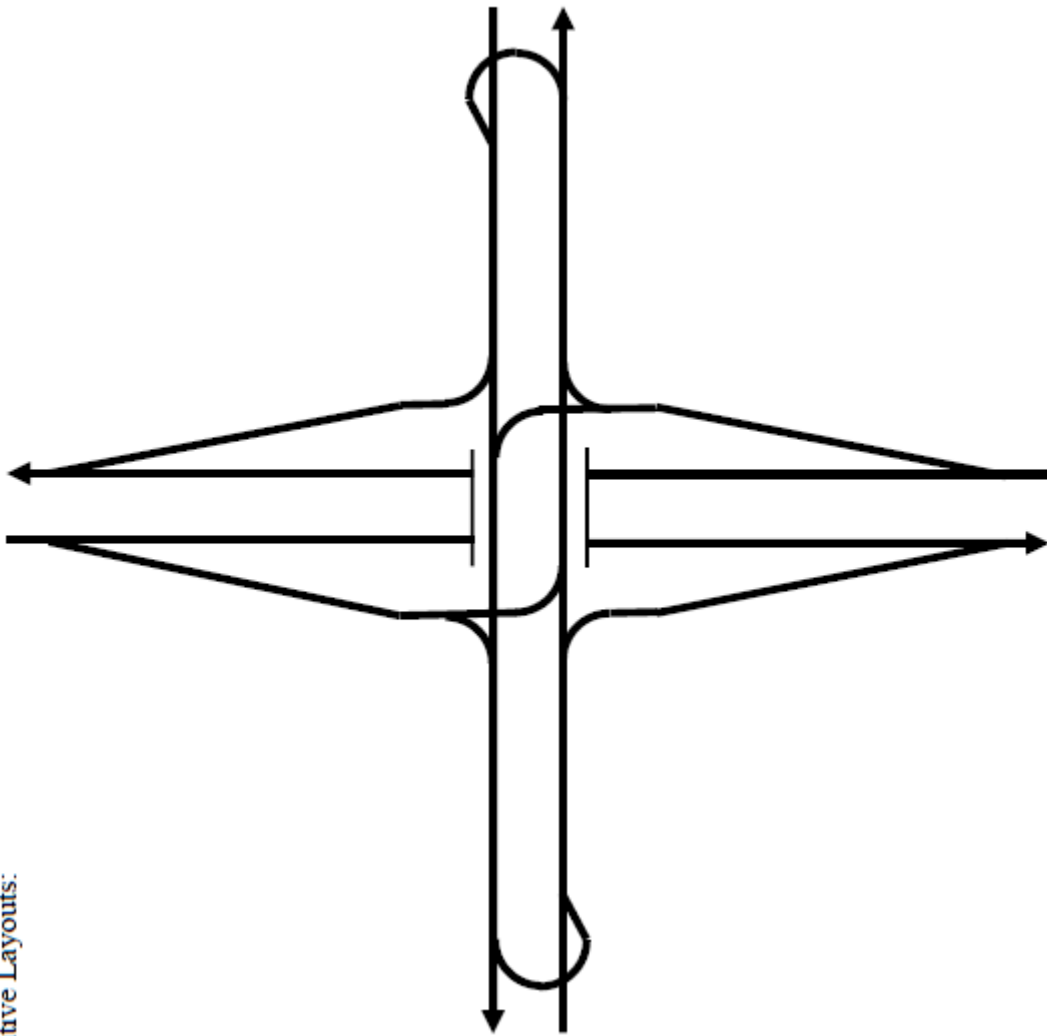
2. Diamond with U-turn for Arterial Lefts

Alternative Layouts:

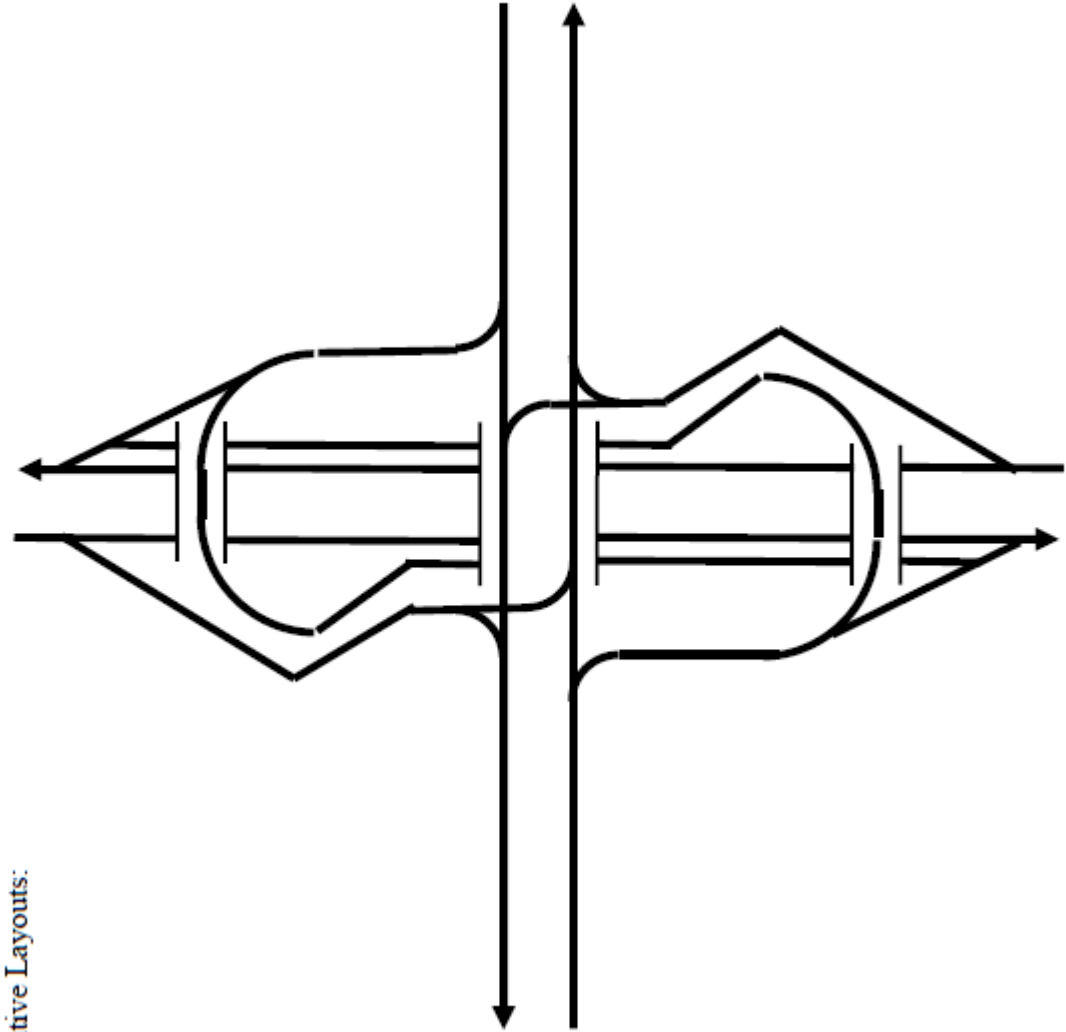
DB

DB.1

DB.2

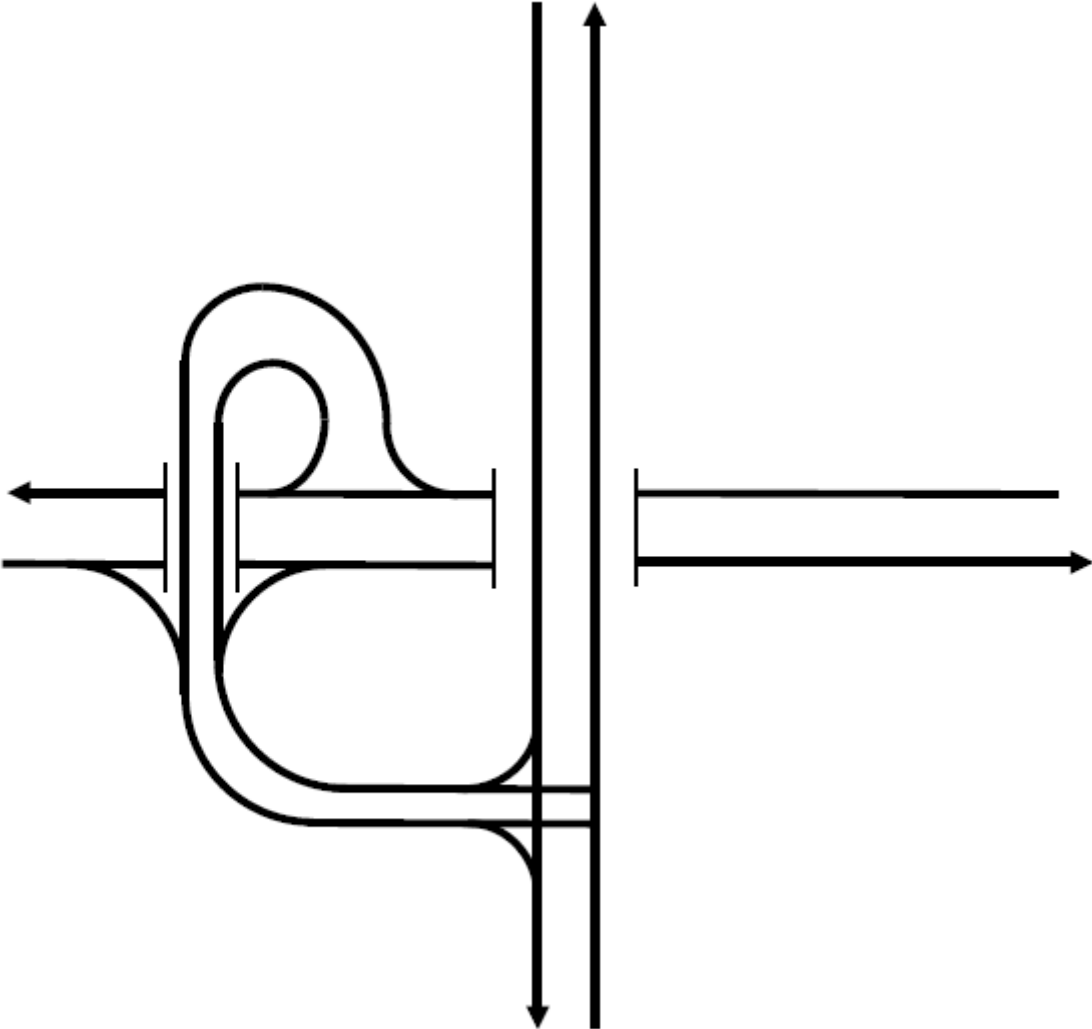


3. Diamond with U-turn over Freeway and Slip Lanes for Arterial Lefts

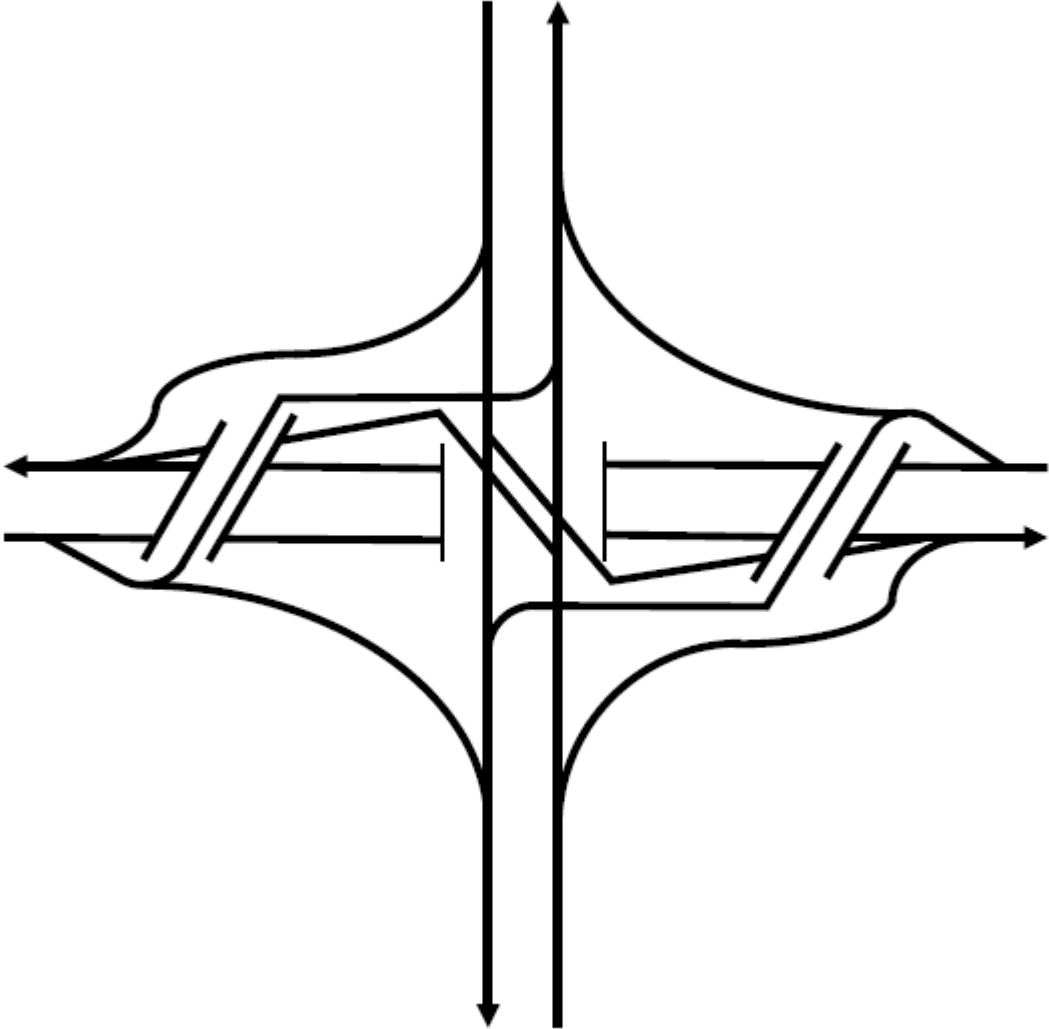


Alternative Layouts:
2B
2B.1
2B.2

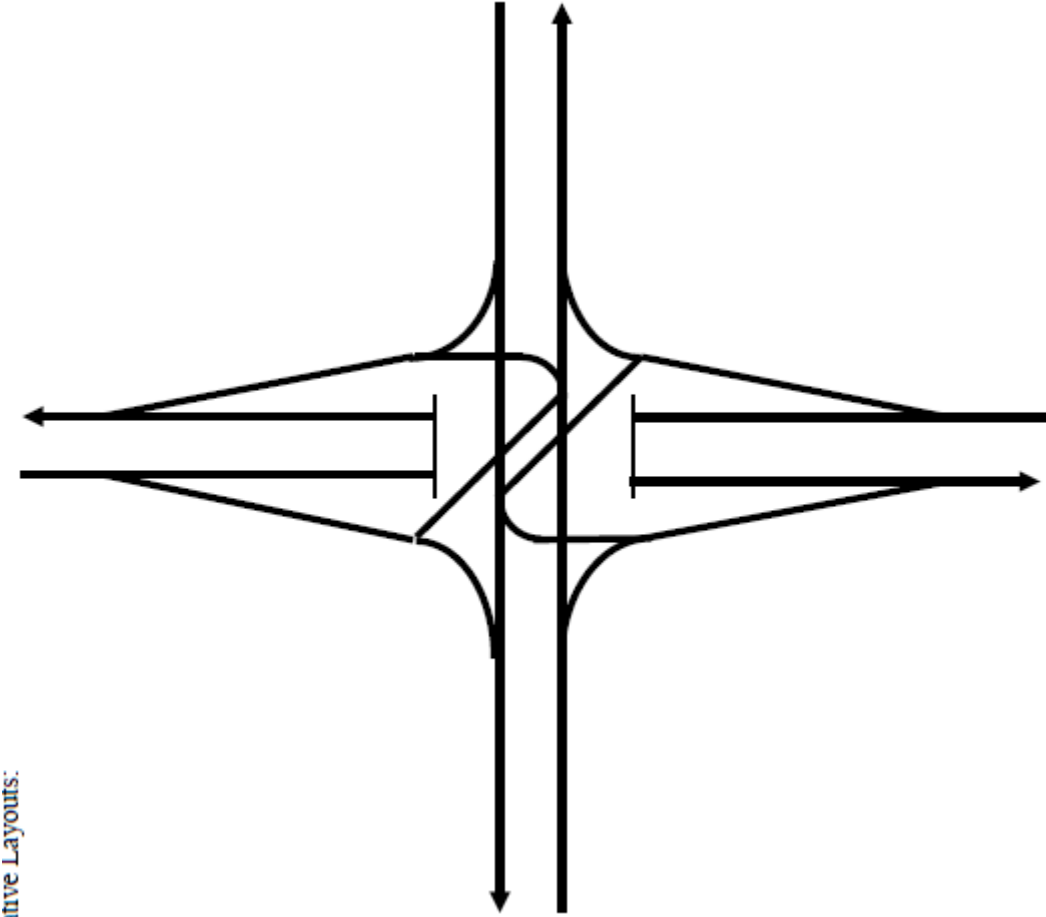
4. Single Quadrant



5. Diamond Single Point with Displaced Ramp Lefts



6. Diamond Single Point/Single Point Urban Interchange (SPUI)



Alternative Layouts:

- 1.1
- 1.2

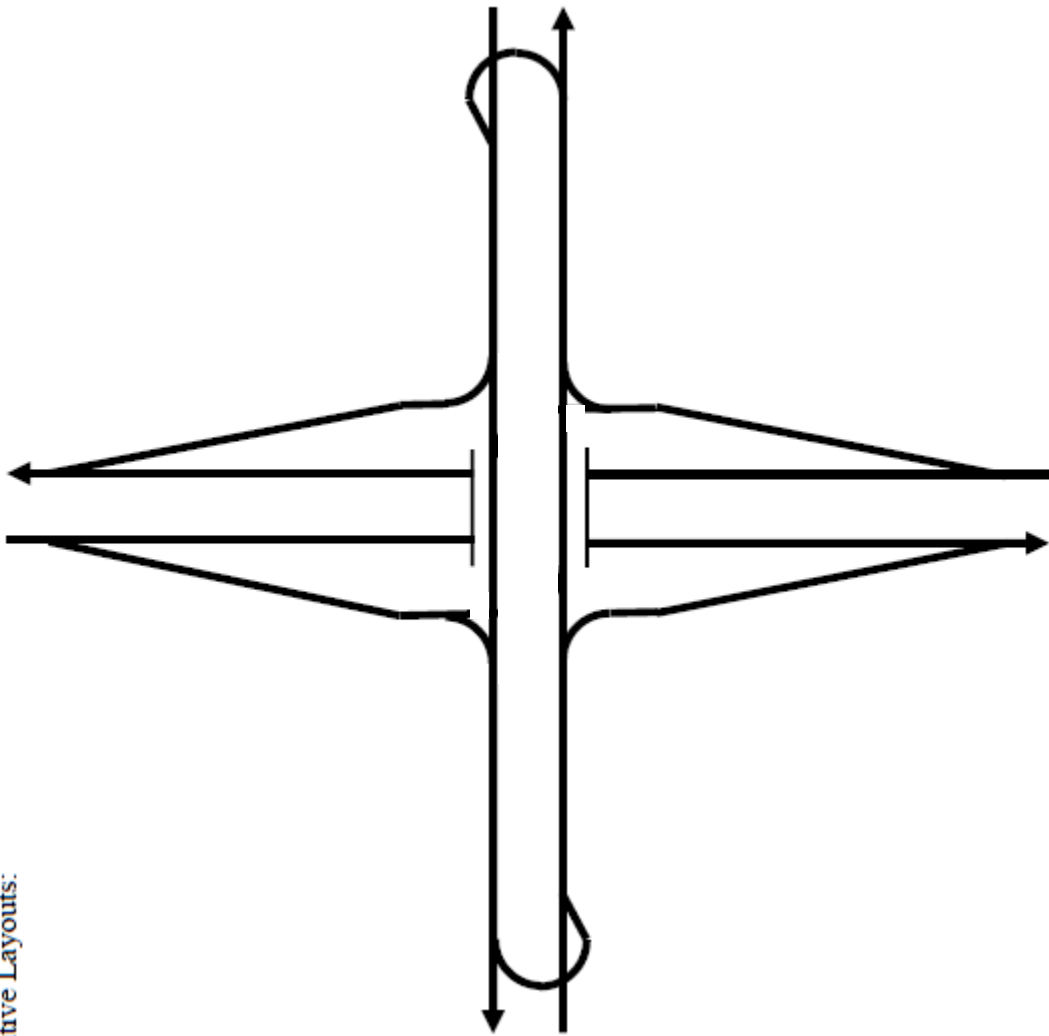
7. Diamond with U-turn for Arterial and Ramp Lefts

Alternative Layouts:

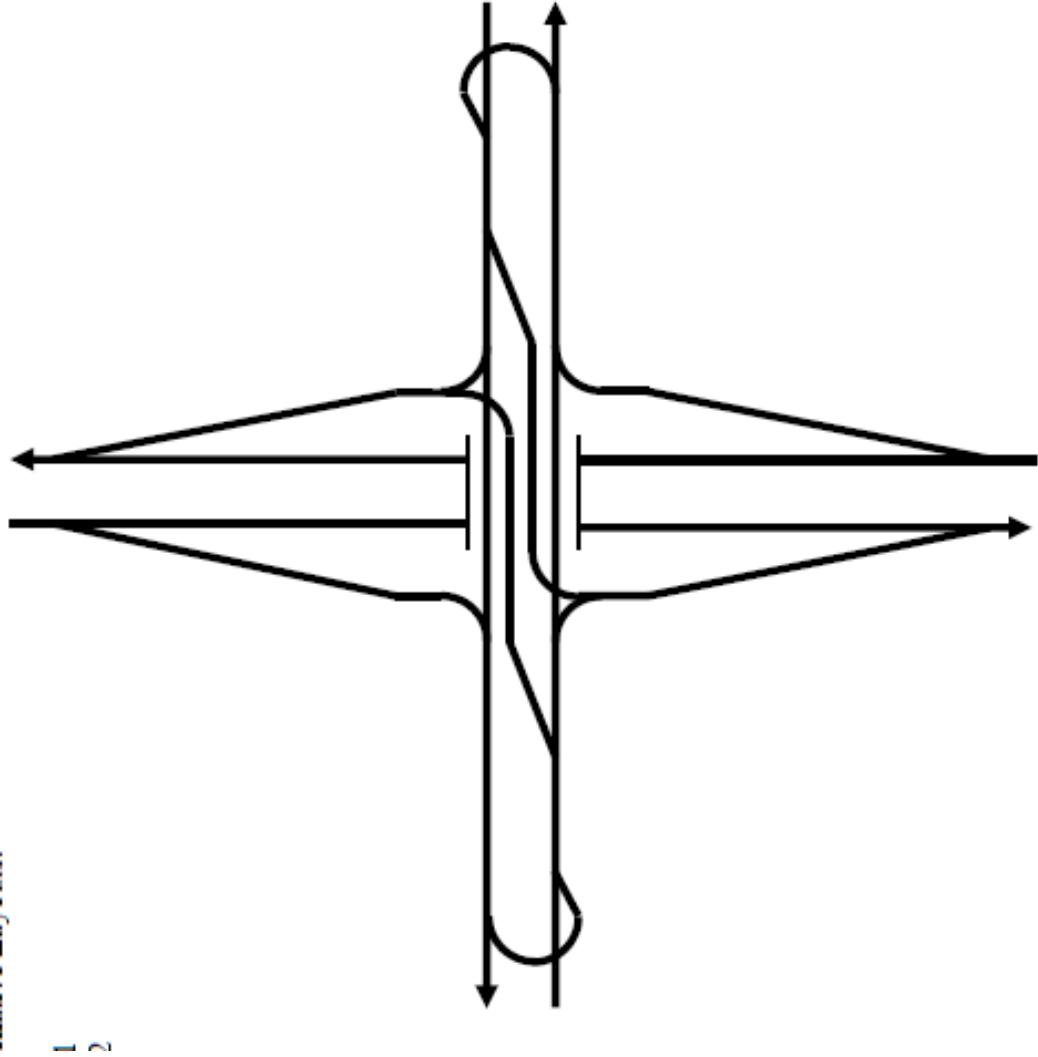
DB

DB.1

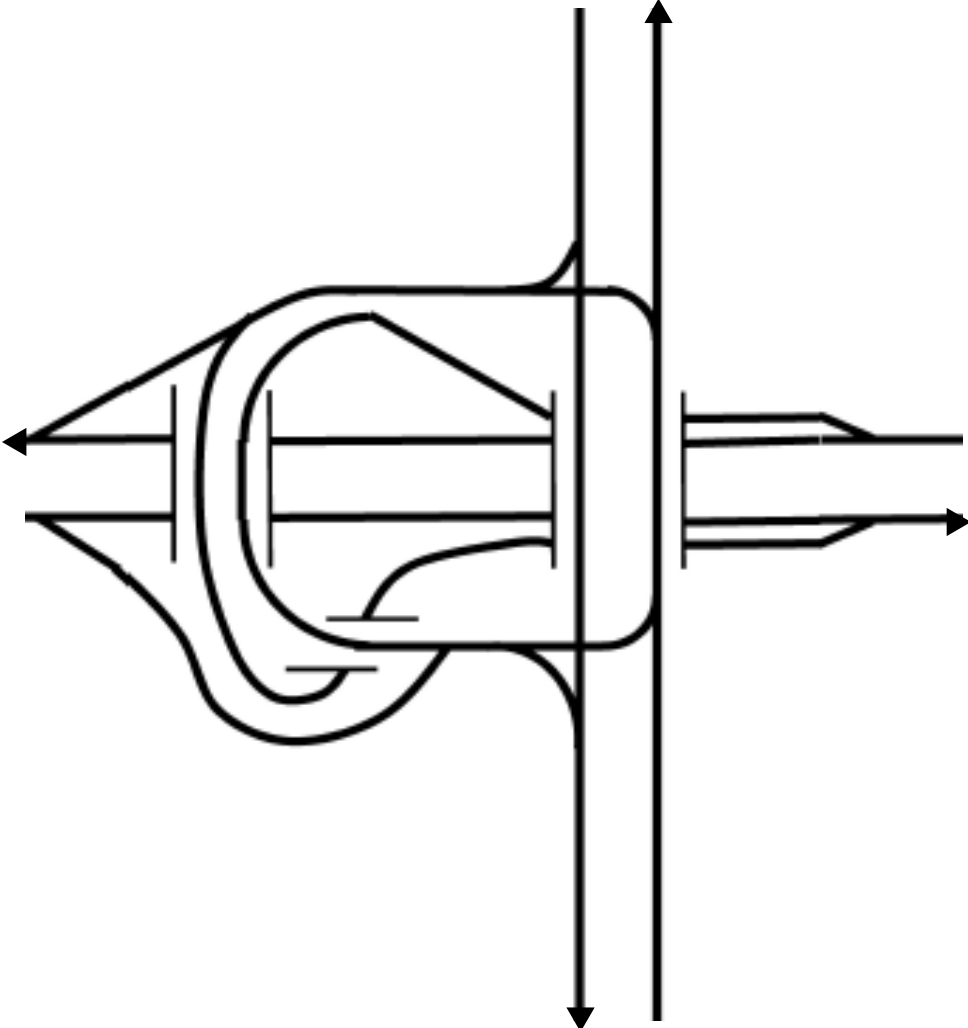
DB.2



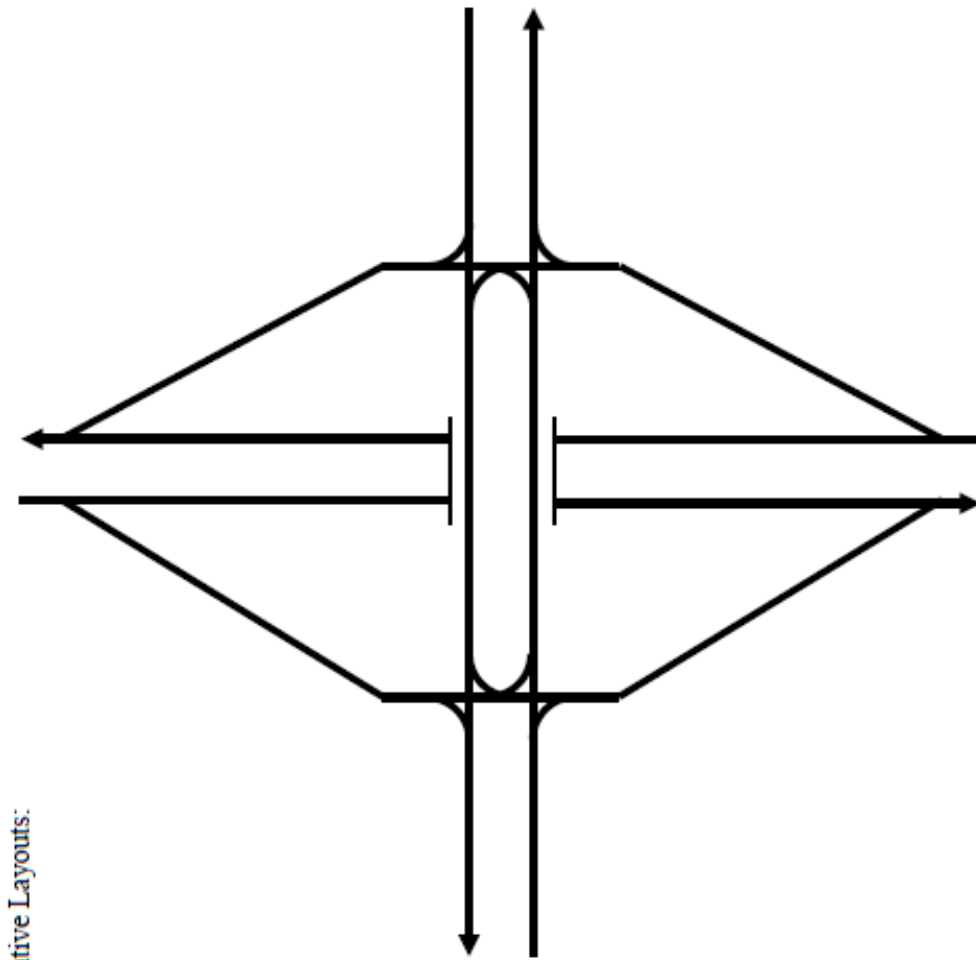
8. Diamond with Contraflow Arterial Lefts and U-turn for Ramp Lefts



9. Elevated Double U-turn

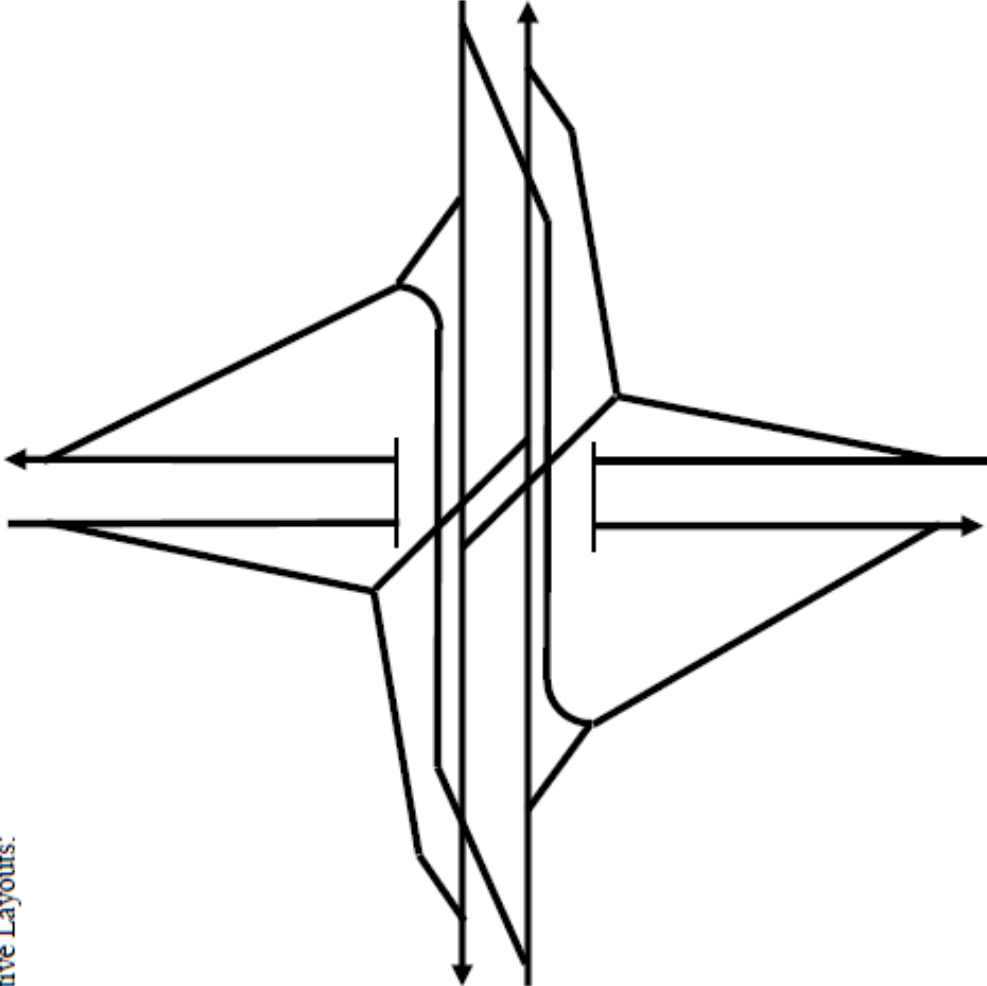


10. Standard Diamond



mative Layouts:

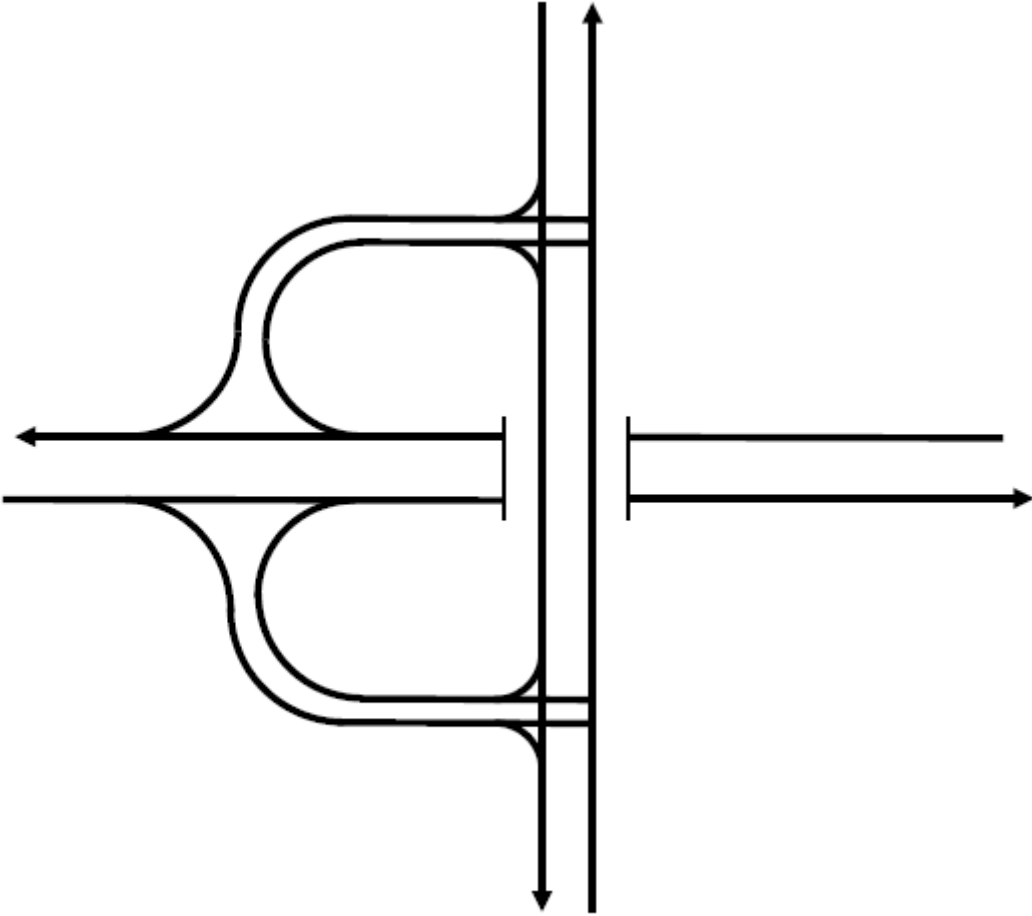
11. Diamond Single Point with Displaced Arterial Lefts



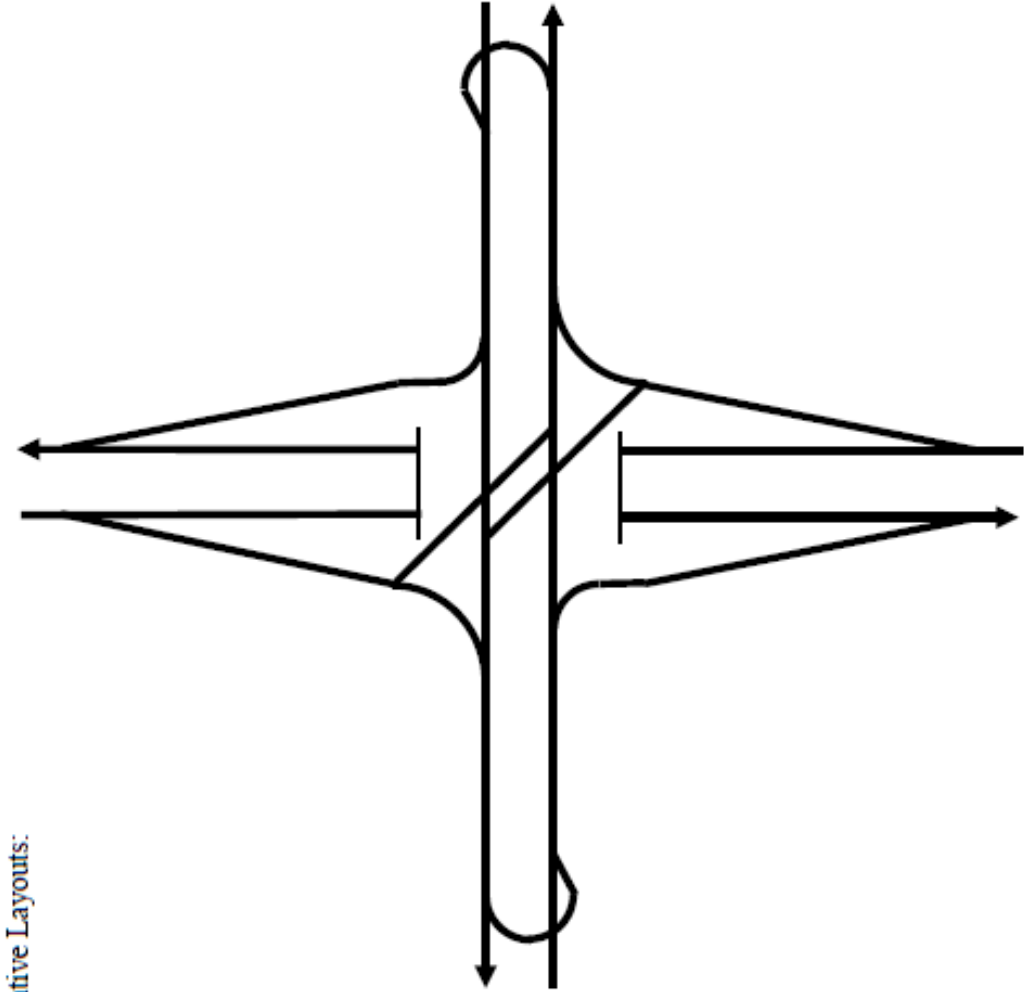
Alternative Layouts:

- A
- A.1
- A.2
- A.3
- A.6

12. Half Clover/Parclo

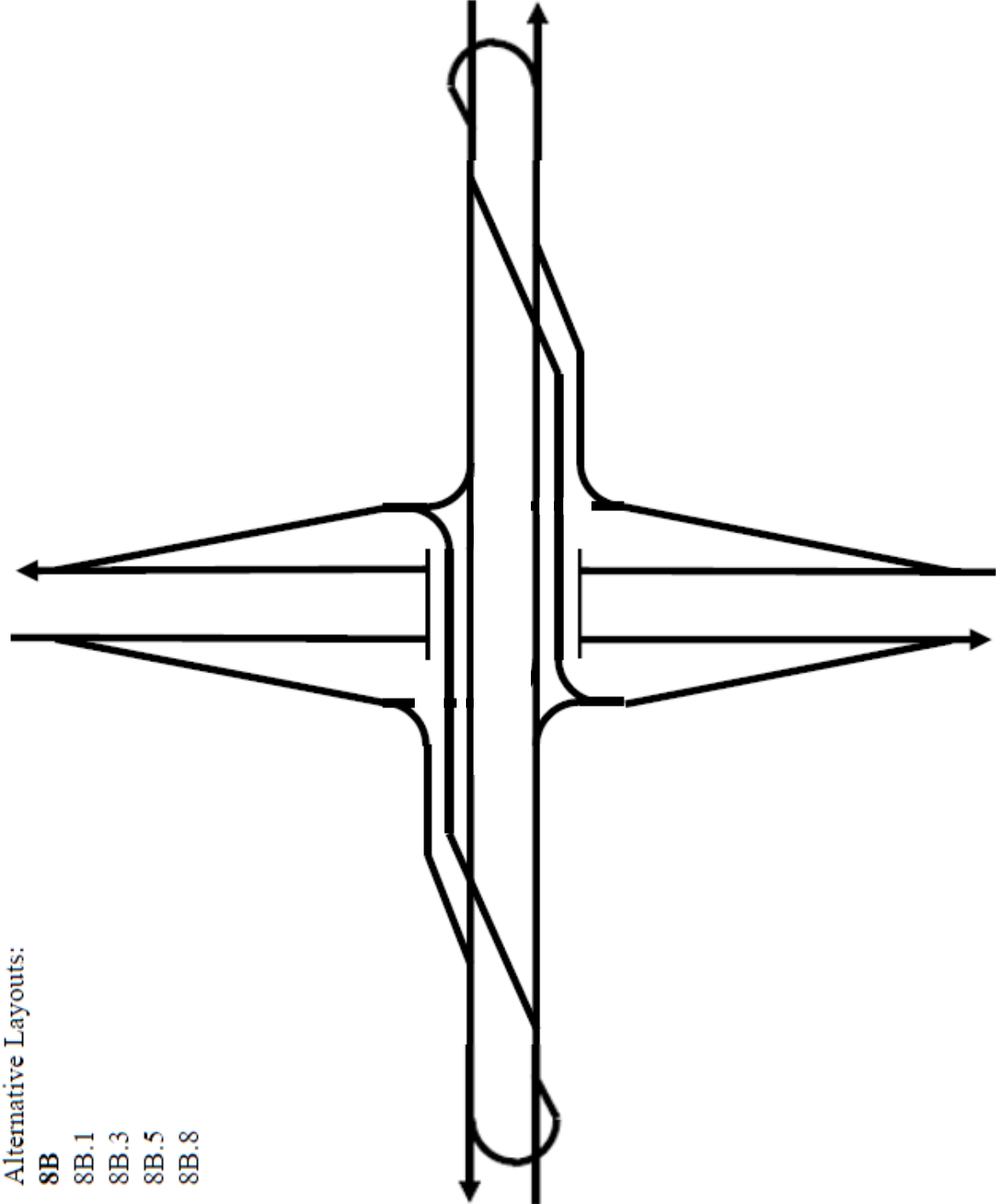


13. Diamond Single Point with U-turn for Arterial Lefts



- Alternative Layouts:
A.1
A.2
A.6
A.7
A.8

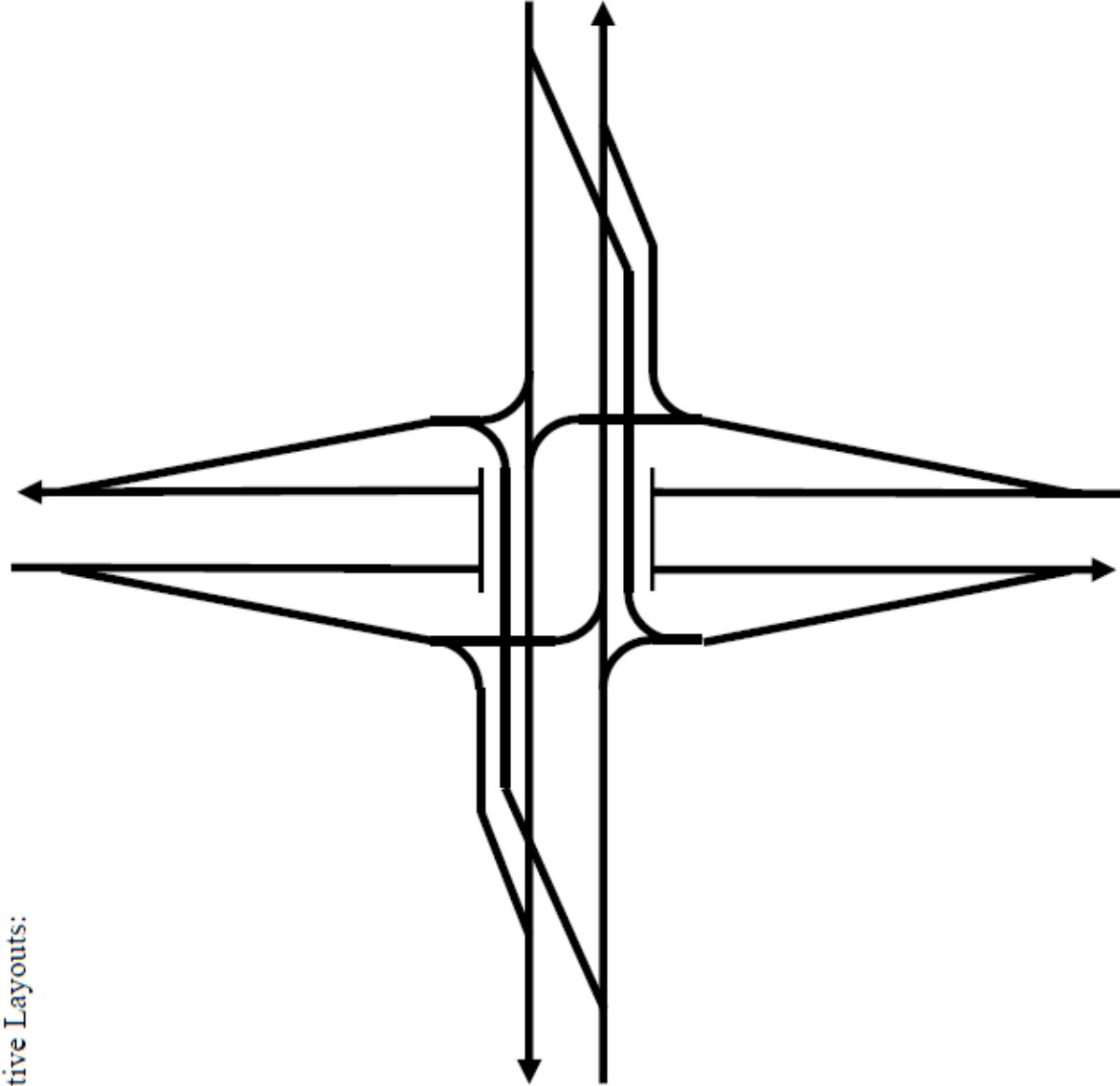
14. Diamond with Displaced Arterial Lefts and U-turn for Ramp Lefts



Alternative Layouts:

- 8B
- 8B.1
- 8B.3
- 8B.5
- 8B.8

15. Diamond with Displaced Arterial Lefts



ernative Layouts:

- 1
- 3
- 5
- 8