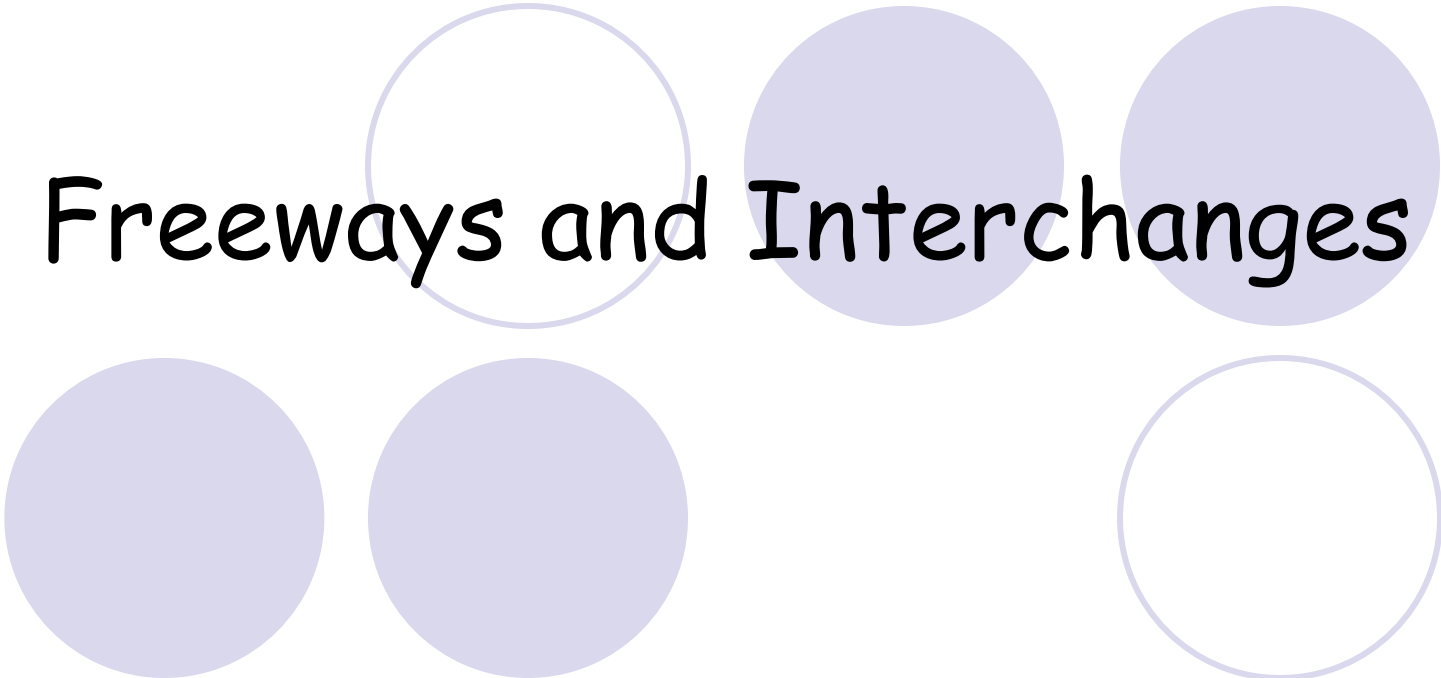




Freeways and Interchanges

Source : *A Policy on
Geometric Design of
Highways and Streets*
(The Green Book).
Washington, DC. American
Association of State
Highway and
Transportation Officials,
2001 4th Ed.



16 lane freeway section (approach to Bay Bridge Toll Plaza, Oakland, CA)

Objectives

- Learn some freeway design standards
- Identify and compare interchange types, advantages/disadvantages
- Identify and describe interchange design principles



Freeways



- Fully access controlled arterials
- Intent: move large volumes of traffic at high speed, safely and efficiently
- At-grade crossings are prohibited

Speed/LOS



- Speed (urban): ≥ 50 mph
- Speed (rural): 70 mph or more
- How does this compare to actual conditions?
- Designed for 20-year volumes
- LOS C: urban
- LOS B: rural

Cross slope and shoulder

- Minimum 2 through lanes 1.5 to 2% cross-slope
- Continuous paved shoulder
 - Right: 10 ft
 - Left: 4 to 8 ft

Grades

Type of Terrain	Metric						US Customary						
	Design Speeds (km/h)						Design Speeds (mph)						
	80	90	100	110	120	130	50	55	60	65	70	75	80
	Grades (%) ^a						Grades (%) ^a						
Level	4	4	3	3	3	3	4	4	3	3	3	3	3
Rolling	5	5	4	4	4	4	5	5	4	4	4	4	4
Mountainous	6	6	6	5	—		6	6	6	5	5	—	—
^a Grades 1% steeper than the value shown may be used for extreme cases in urban areas where development precludes the use of flatter grades and for one-way downgrades except in mountainous terrain.													

Exhibit 8-1. Maximum Grades for Rural and Urban Freeways

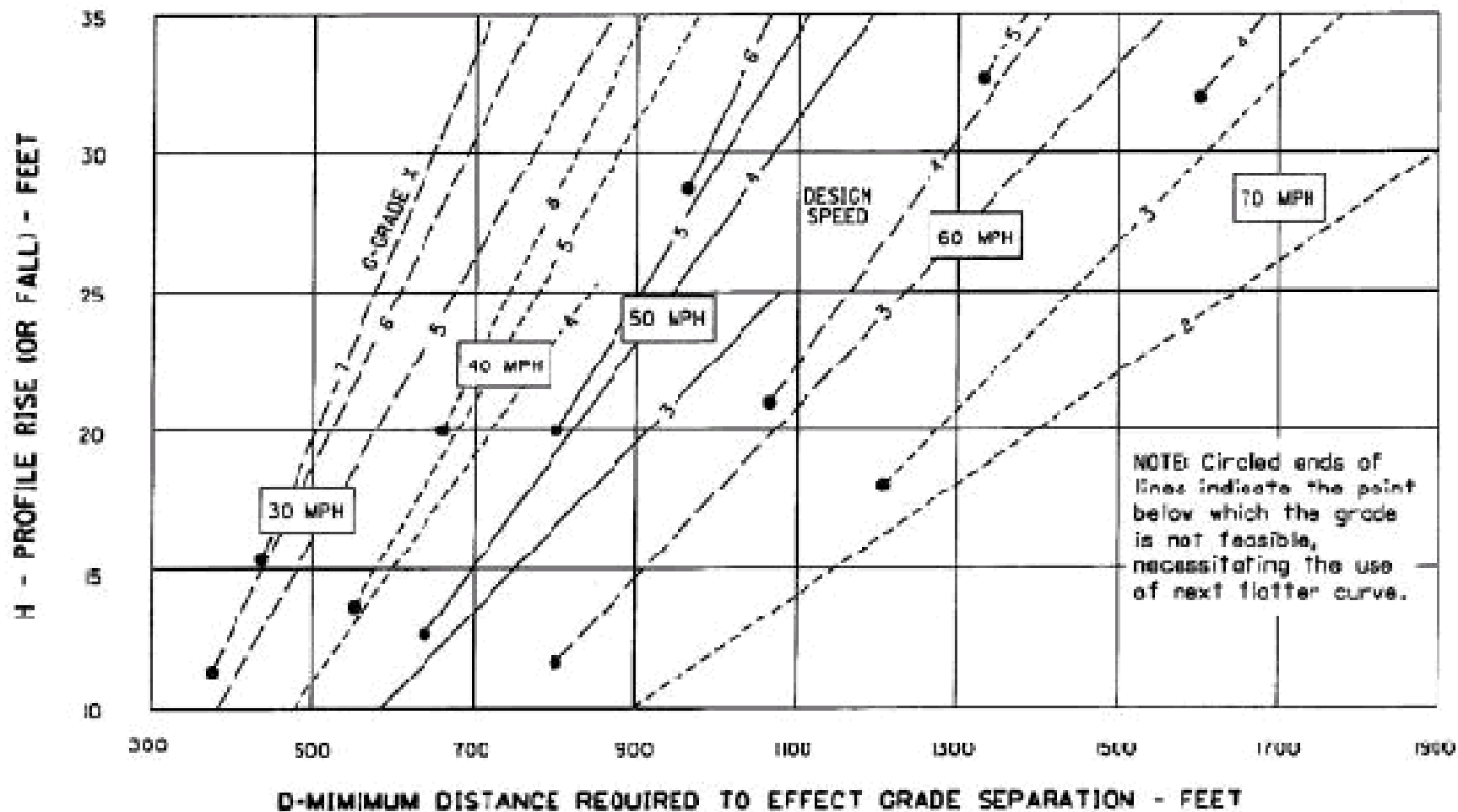


Exhibit 10-8. Flat Terrain, Distance Required to Effect Grade Separation

Clearance

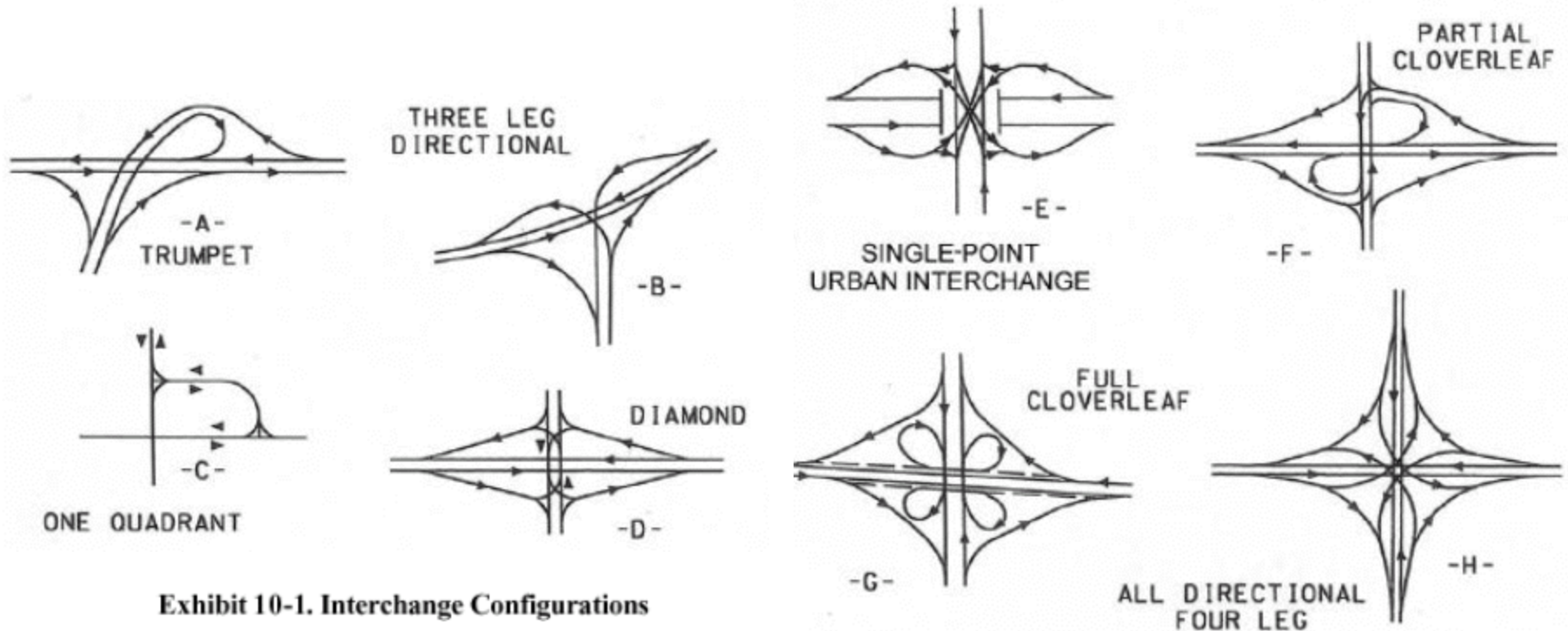
- Vertical clearance: at least 16' over entire cross-section
 - Consider future resurfacing
- Horizontal: clear zone consistent with operating speed and side slopes
- Medians:
 - Rural: 50 to 100 ft
 - Urban
 - For 4 lane use 10' (2x4' shoulder + barrier)
 - For 6 lane use 22' (2x10' shoulder + barrier)

Just for fun .. Ole lived across the river from Clarence, who he didn't like at all. They all the time were yelling across the river at each other. Ole would yell to Clarence, "If I had a way to cross dis river, I'd come over dere an beat you up good, yeah sure ya betcha by golly!" This went on for years. Finally the state built a bridge across the river right there by their houses. Ole's wife, Lena, says, "Now is you chance, Ole, vhy don't you go over dere and beat up dat Clarence like you said you vood?" Ole says, "OK, by yimmy, I tink I vill do yust dat". Ole started for the bridge but he sees a sign on the bridge an he stops to read it, then he turns around and comes back home. Lena asked, "vhy did you come back?" Ole said, "Lena, I tink I change my mind 'bout beatin' up dat Clarence, you know, dey put a sign on da bridge dat says "Clarence is 13 ft. 6 in." You know, he don't look near dat big when I yell at him from across da river"

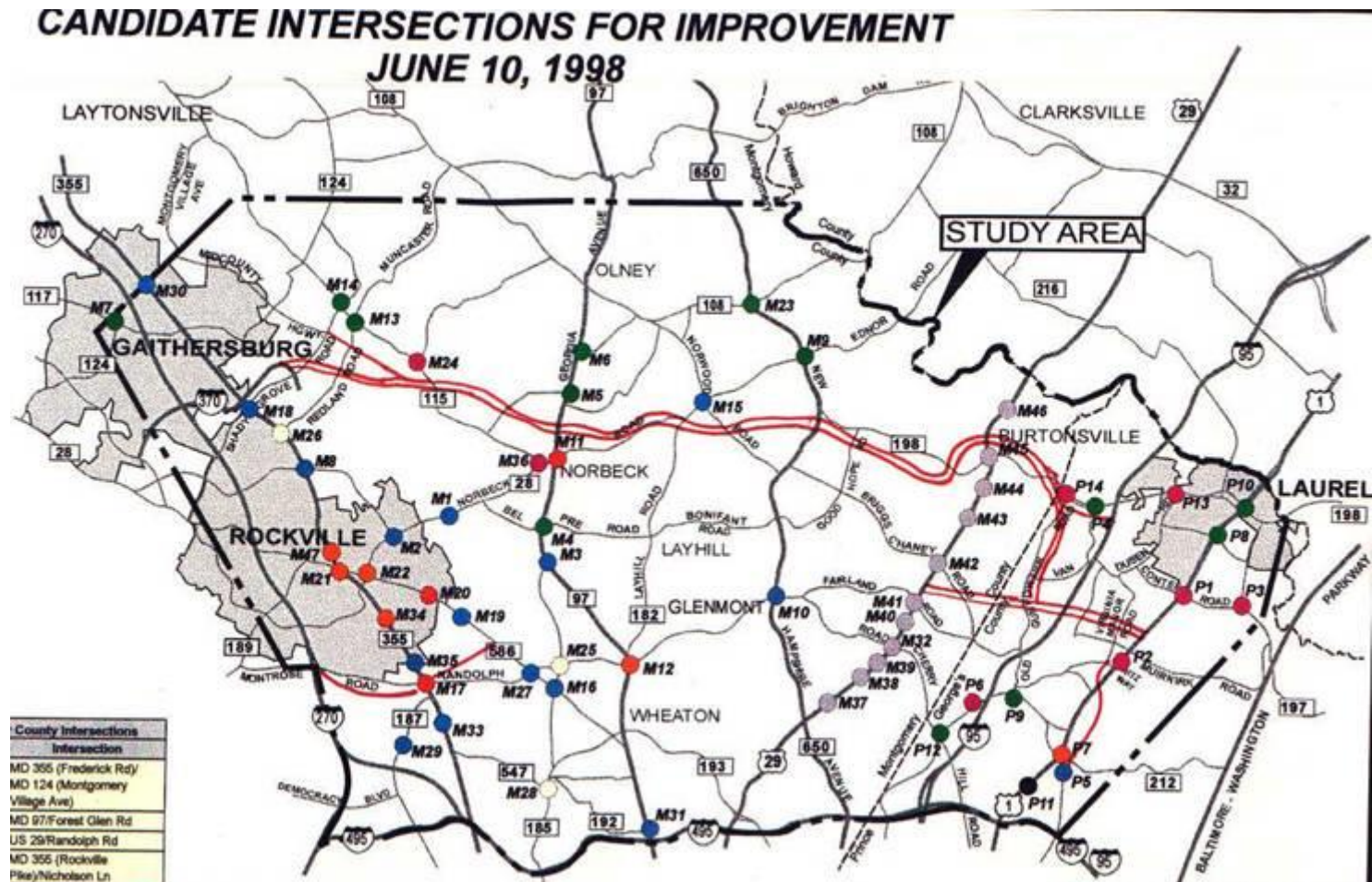
Interchanges

Source of figures and reference for text: *A Policy on Geometric Design of Highways and Streets* (The Green Book). Washington, DC. American Association of State Highway and Transportation Officials, 2001 4th Ed.

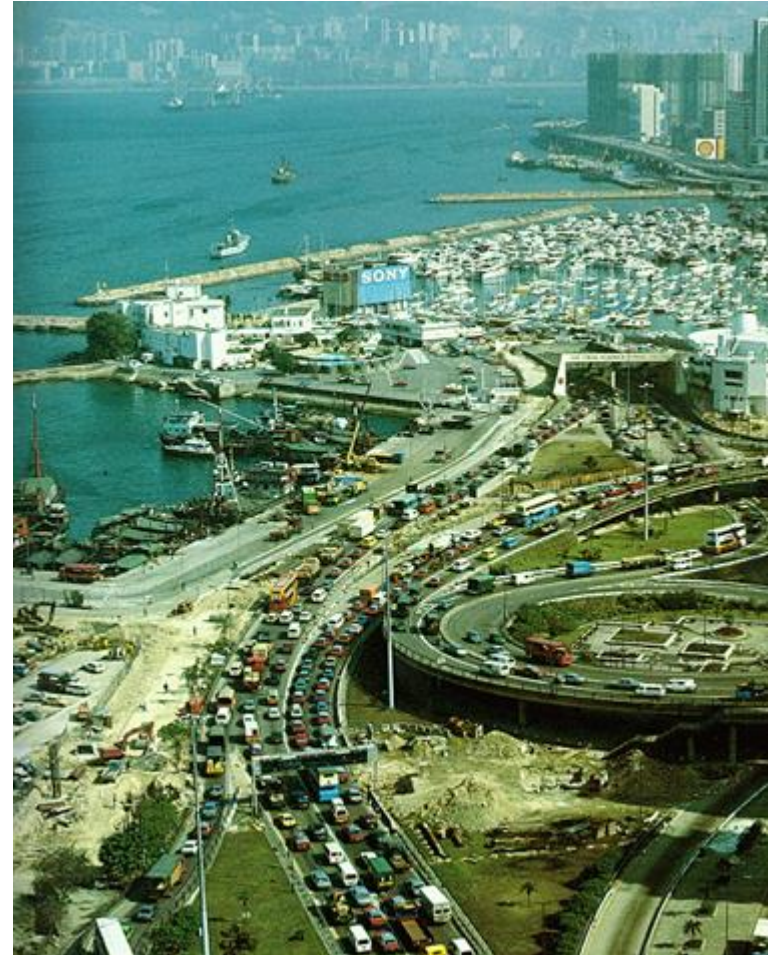
- grade separations with connecting roadways for turning movements



Interchange Warrant #1: Design Designation



Warrant #2: congestion



Warrant #3: safety



Warrant #4: topography



Dear Sarah,
I hope this picture will
bring back to you the
days here on the hill.
I am enjoying my
time touring the hills.
It is a beautiful day to
travel and I really have
thought it best about
that you will enjoy
the hills. We are so close
now and will be ready to
go home about 1:30 or
1:45 from now. I am
sure you will enjoy
up our new line.

POST CARD



Ramp Types

- Diagonal
- one-quadrant ramp
- Semidirectional
- outer connection
- Directional
- Loops

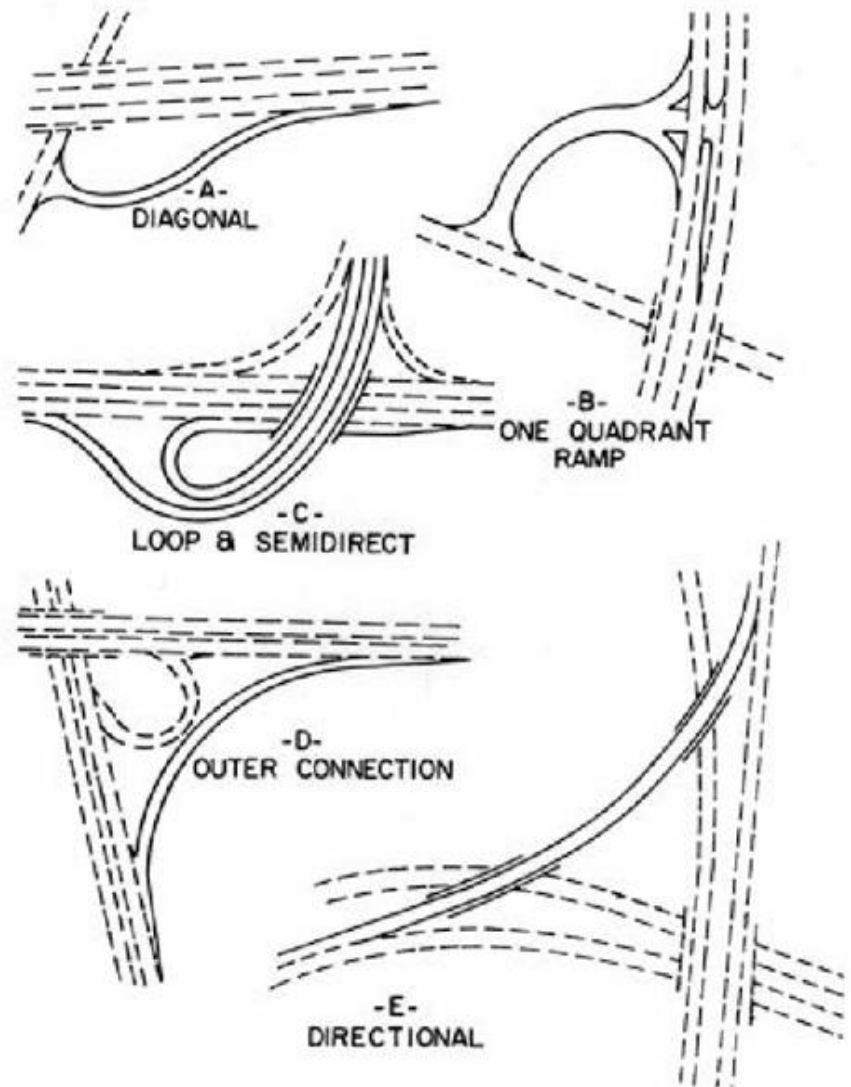


Exhibit 10-55. General Types of Ramps



Exhibit 10-65. Gore Area, Two-Lane Exit

Interchange types

- System (freeway to freeway - directional)
- Service (freeway to arterial or collector - diamond, cloverleaf, etc.)

TYPE OF INTERSECTING FACILITY		RURAL	SUBURBAN	URBAN
LOCAL ROAD OR STREET	SERVICE INTERCHANGES			
COLLECTORS AND ARTERIALS				
FREEWAYS	SYSTEMS INTERCHANGES			

Exhibit 10-43. Adaptability of Interchanges on Freeways as Related to Types of Intersecting Facilities

Diamond

- Use where intersection can handle left turns
- Simplest (and usually cheapest)
- One-way diagonal ramp in each quadrant for all turning movements
- Ramp originates/terminates at either at-grade intersection with cross street or junction with frontage road

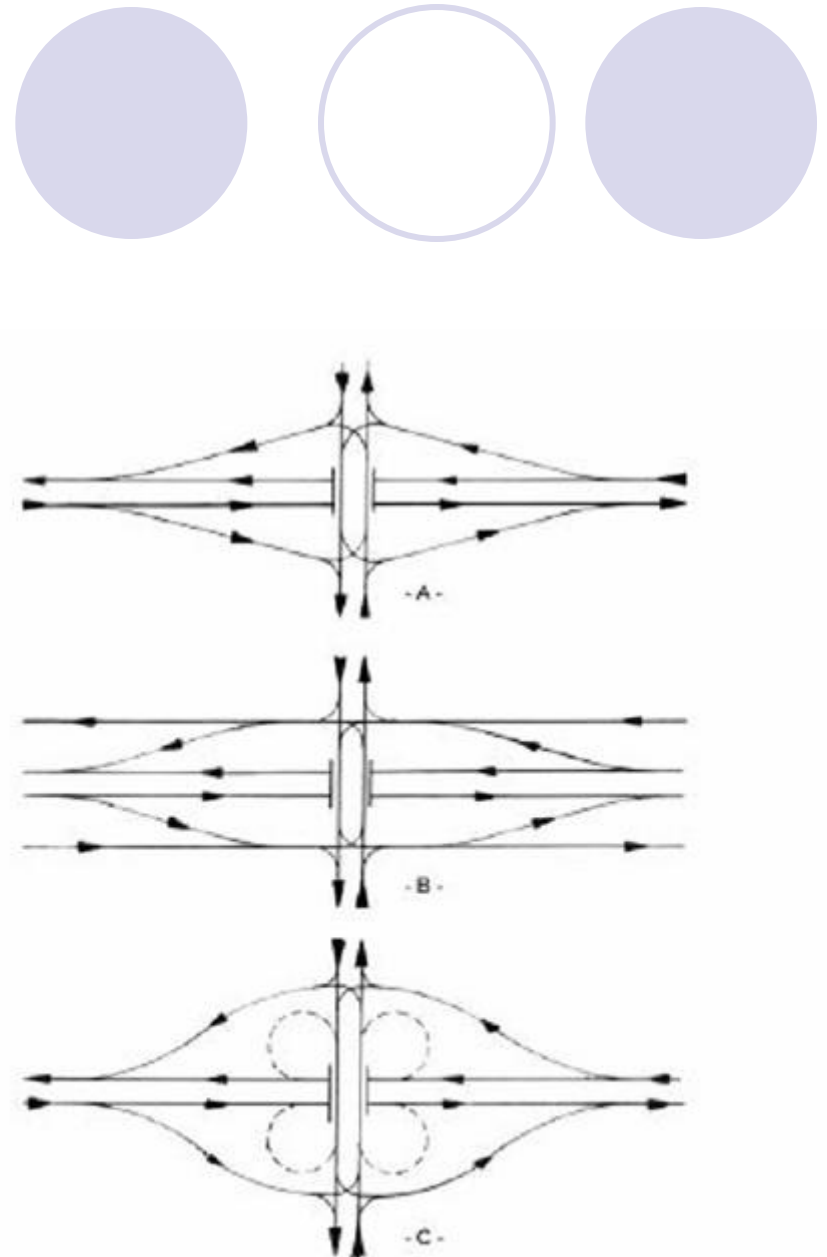


Exhibit 10-16. Diamond Interchanges, Conventional Arrangements

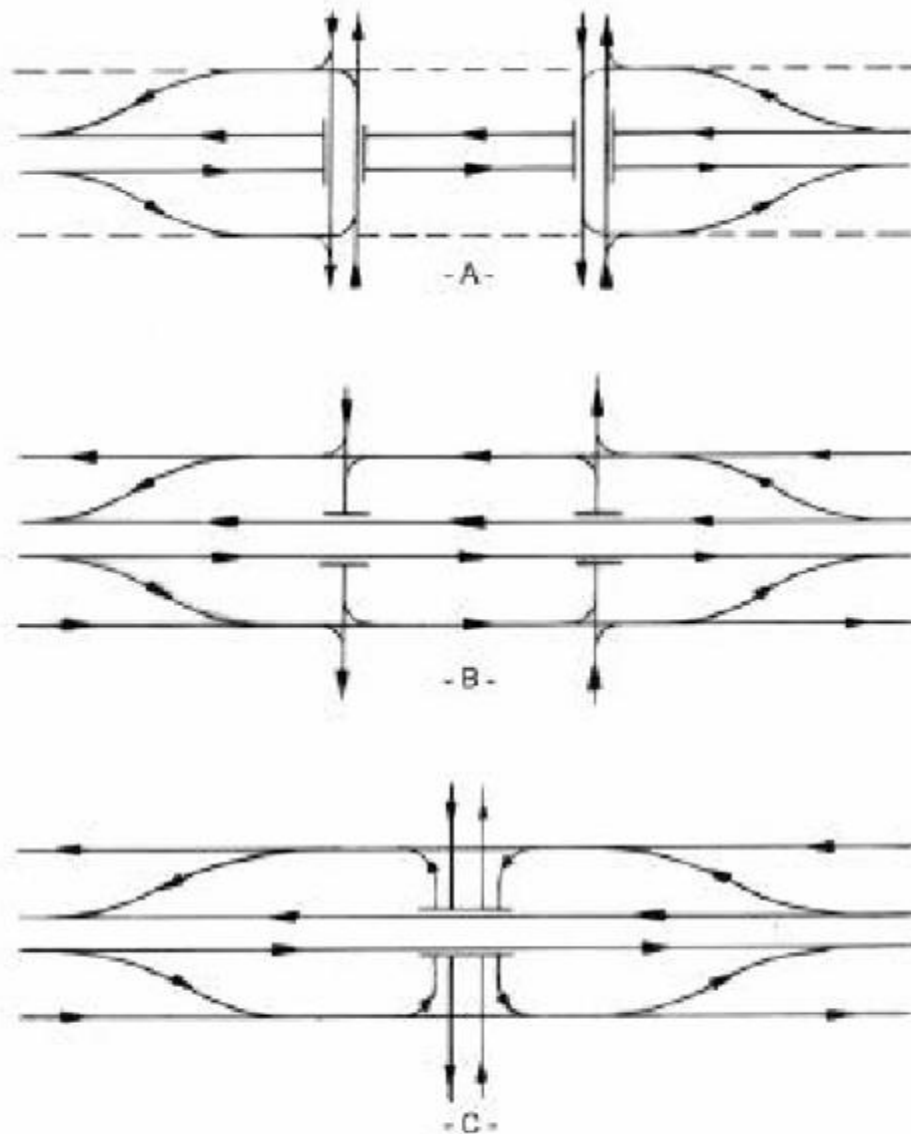


Exhibit 10-17. Diamond Interchange Arrangements to Reduce Traffic Conflicts

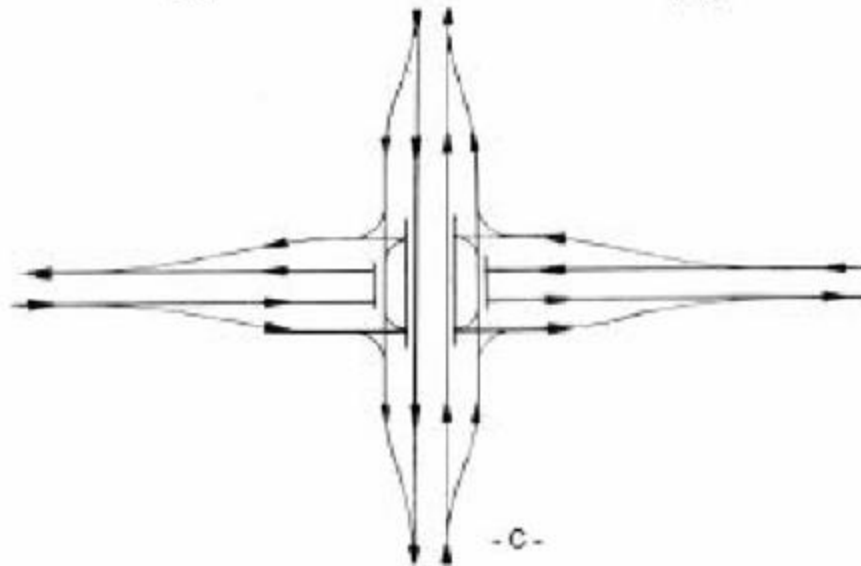
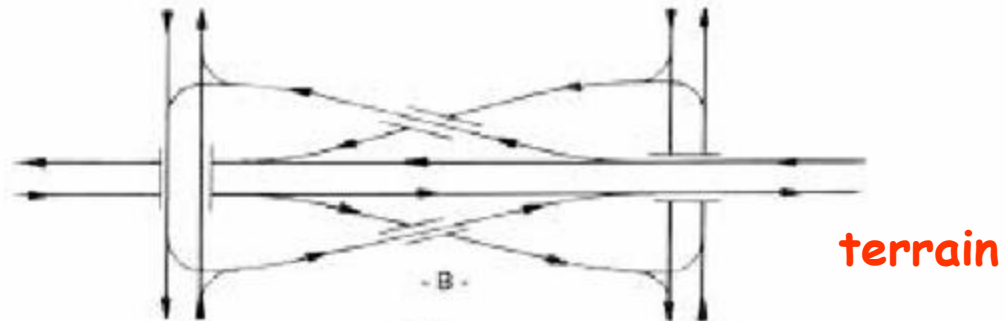
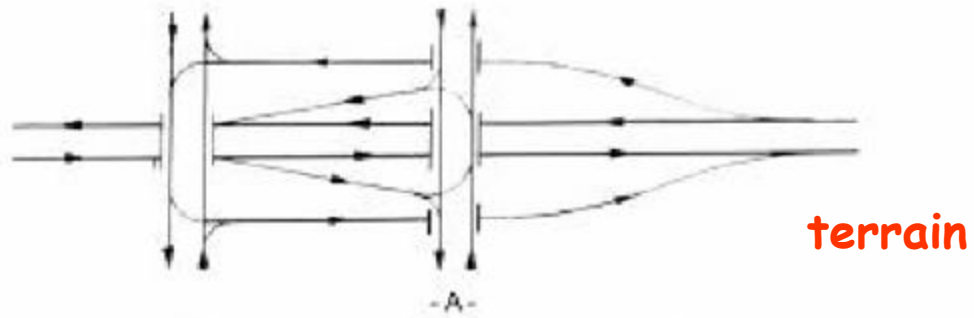


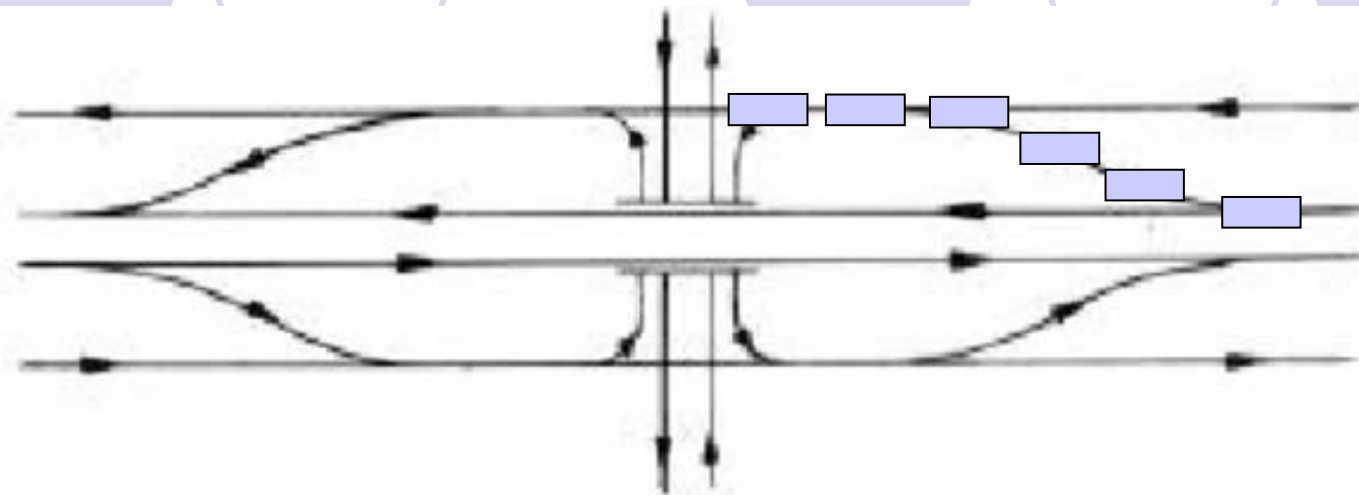
Exhibit 10-18. Diamond Interchanges with Additional Structures

Use overpass or underpass?

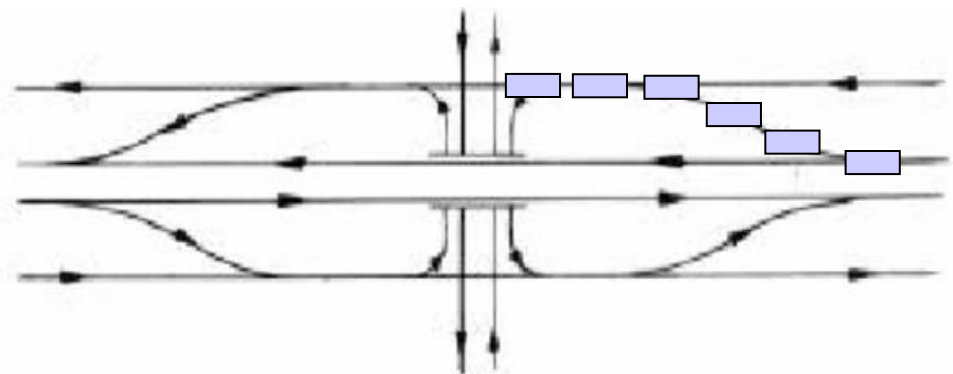
- Depends on topography, economy, and other minor factors
 - Underpass better for deceleration/acceleration, cost, and advance warning
 - Overpass better for aesthetics



Problem with the Diamond ...



Possible solution?



Type of Terrain	Metric						US Customary							
	Design Speeds (km/h)						Design Speeds (mph)							
	80	90	100	110	120	130	50	55	60	65	70	75	80	
	Grades (%) ^a						Grades (%) ^a							
Level	4	4	3	3	3	3	4	4	3	3	3	3	3	
Rolling	5	5	4	4	4	4	5	5	4	4	4	4	4	
Mountainous	6	6	6	5	-		6	6	6	5	5	-	-	

^a Grades 1% steeper than the value shown may be used for extreme cases in urban areas where development precludes the use of flatter grades and for one-way downgrades except in mountainous terrain.

Exhibit 8-1. Maximum Grades for Rural and Urban Freeways

Solution #1: Cloverleaf

- Full and partial
- apply where left turns can't be served (possibly physically) at an intersection and there is the available ROW
- Loops accommodate LTs



Exhibit 10-26. Four-Leg Interchange, Full Cloverleaf With Collector-Distributor Roads



http://www.thenewi64.org/1c4_sp21.jsp

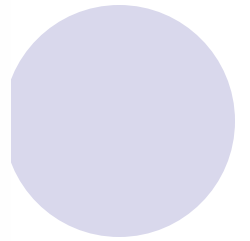
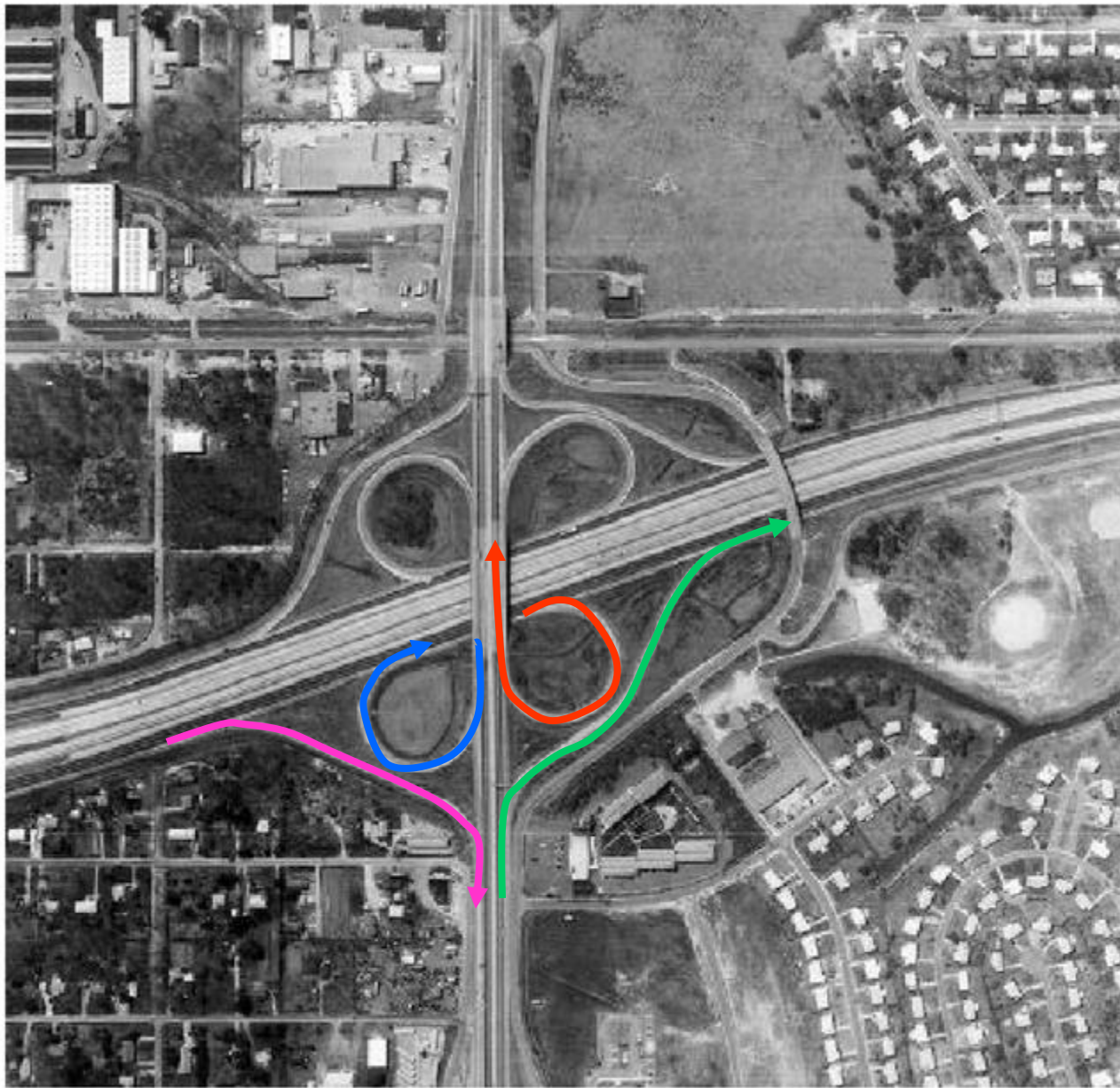


Exhibit 10-27. Cloverleaf Interchange With Collector-Distributor Roads

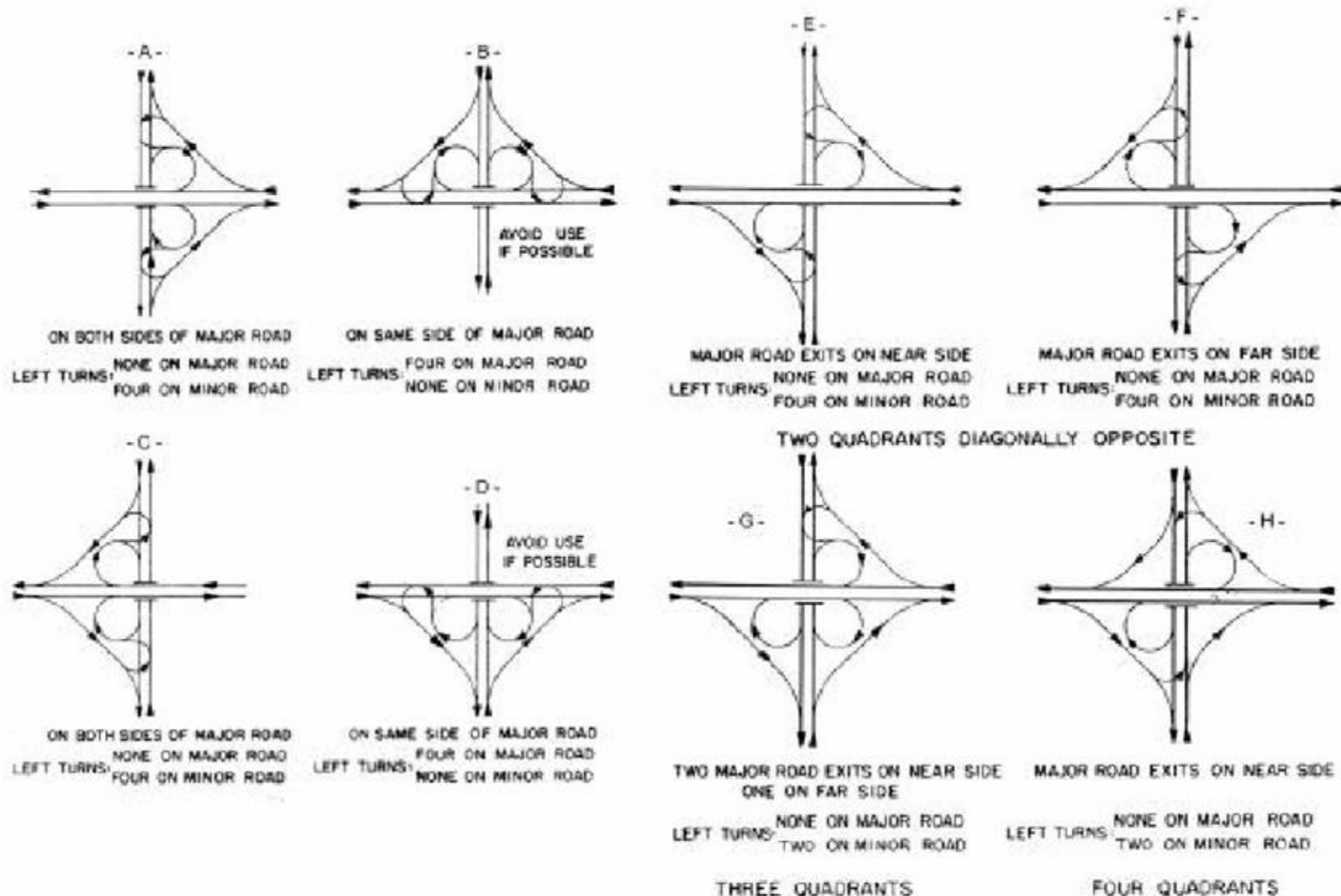


Exhibit 10-28. Schematic of Partial Cloverleaf Ramp Arrangements, Exit and Entrance Turns



Exhibit 10-29. Four-Leg Interchange (Partial or Two-Quadrant Cloverleaf with Ramps Before Main Structure)

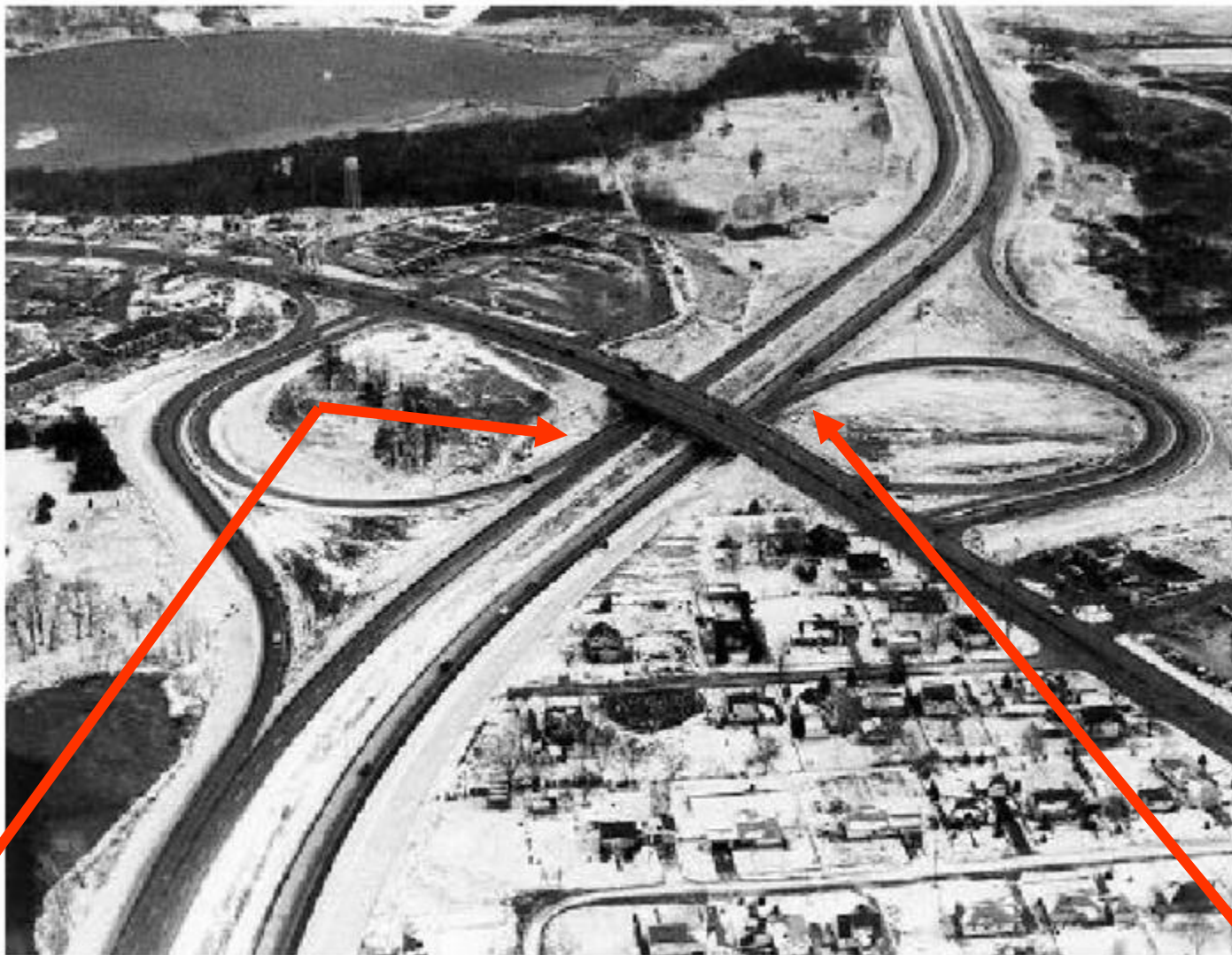
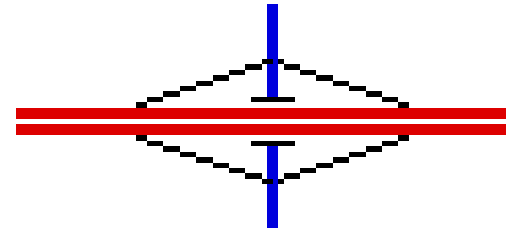


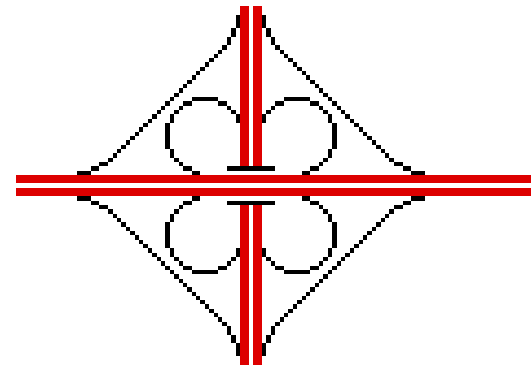
Exhibit 10-30. Four-Leg Interchange (Partial or Two-Quadrant Cloverleaf with Ramps Beyond Main Structure)

Advantages of Diamond Over Cloverleaf

- Requires less ROW
- left-turns travel less distance
- high speed exit/entrance
- has expected exit/enter pattern (versus cloverleaf with unexpected pattern and weave section)
- No weaving section



Classic diamond.

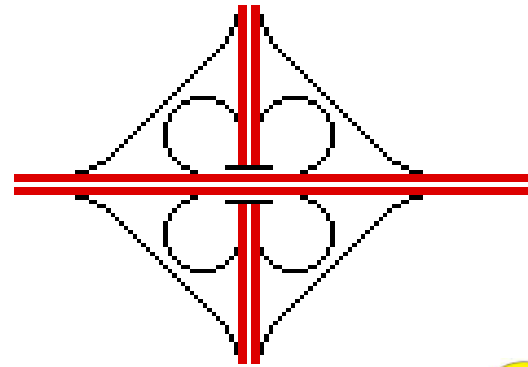


Full Cloverleaf.

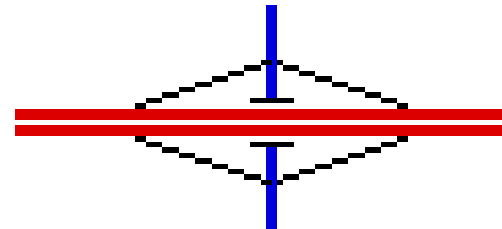


Advantages of Cloverleaf over Diamond

- left turns merge at acute angles
- Higher left turn capacity
- turning vehicles may not have to stop
- don't need median/signs to prevent wrong way entrance



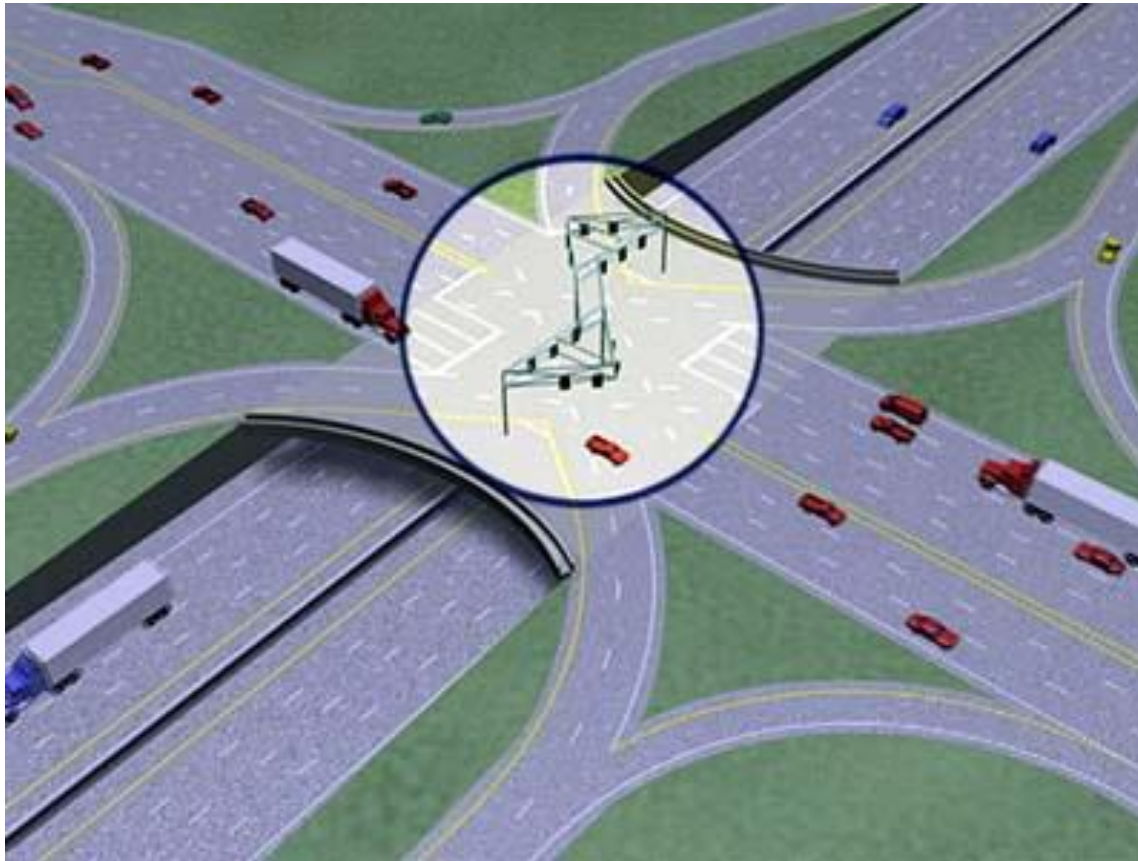
Full Cloverleaf.



Classic diamond.



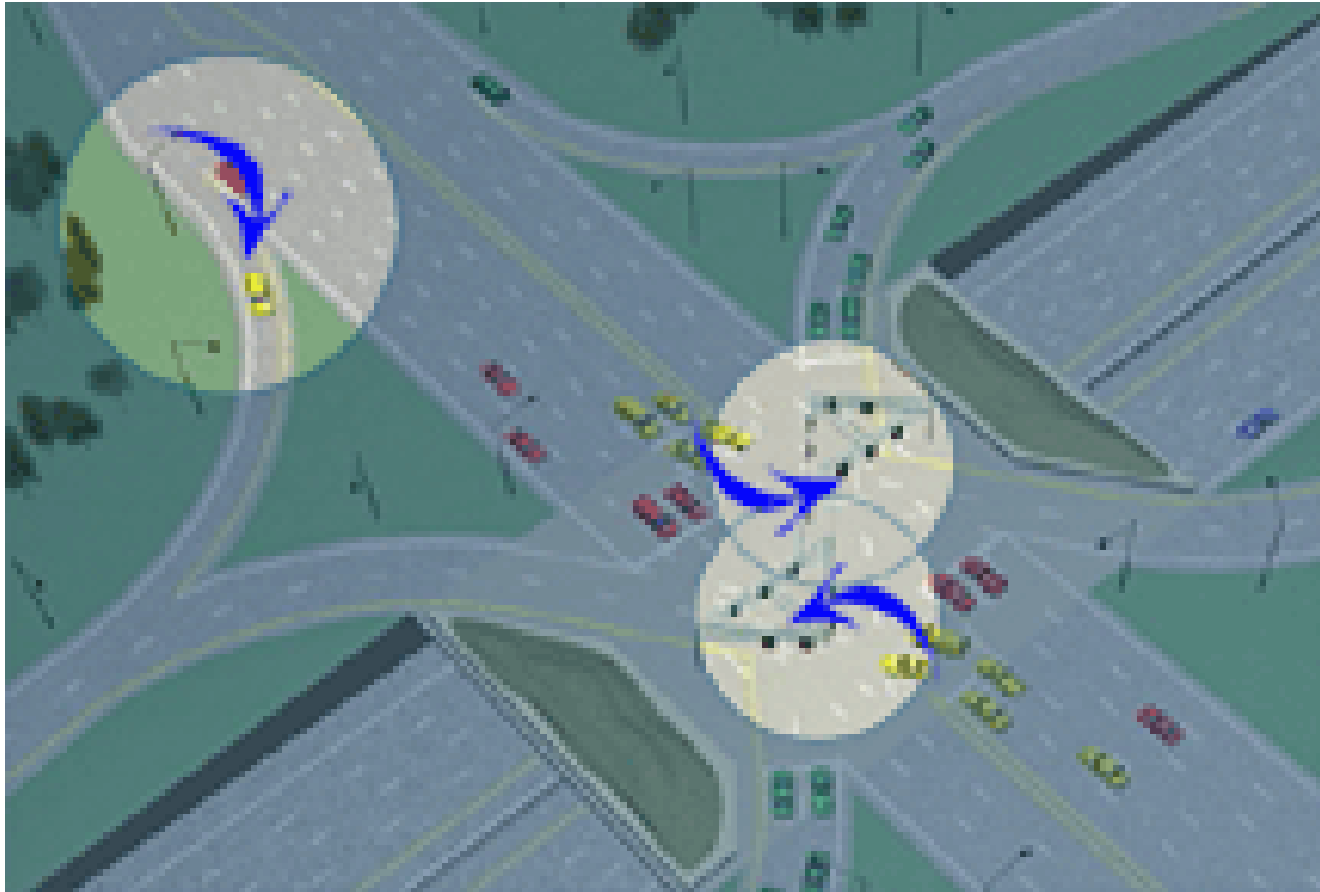
Solution 2: Single Point Urban Interchange?



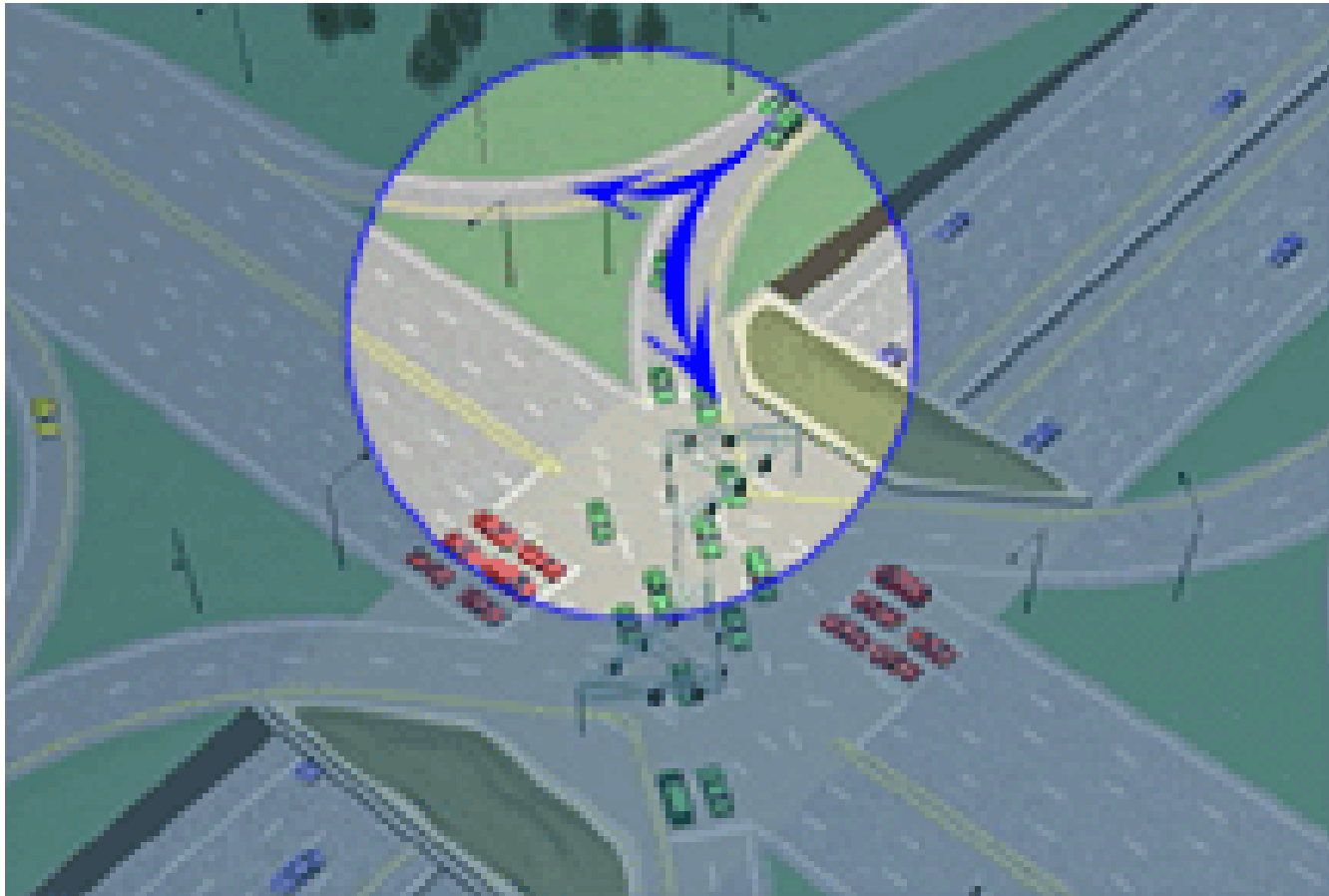
A Single Point Urban Interchange (SPUI) is controlled by one set of traffic signals (highlighted) located at a single point at the center of the interchange. The signals direct thru-traffic, as well as all traffic that must turn left to enter or leave the freeway

http://www.thenewi64.org/1c4_spui.jsp

Traffic enters the freeway by turning left at the traffic signals, or by turning right onto the access ramps



Exit ramps from the freeway divide left and right as they approach the local road. Traffic turning left is controlled by traffic signals at the single point.



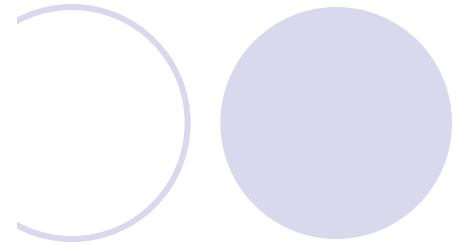
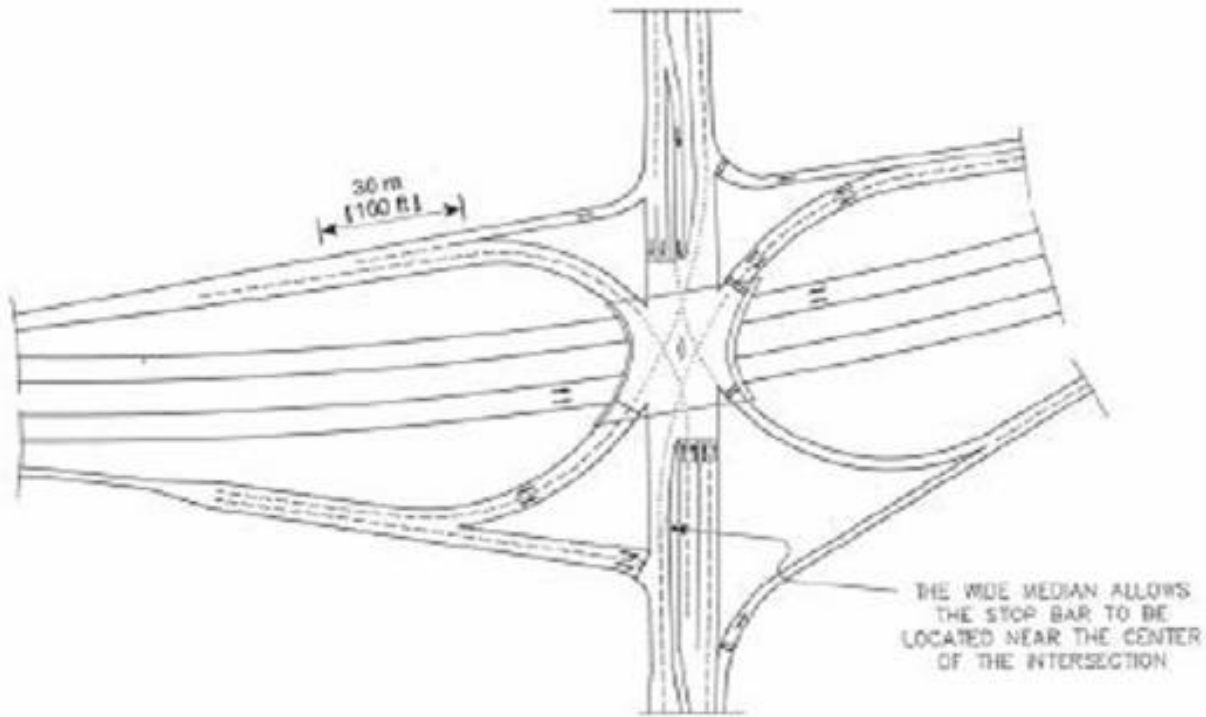


Exhibit 10-22. **Underpass** Single Point

Short span, wide deck



Underpass SPUI



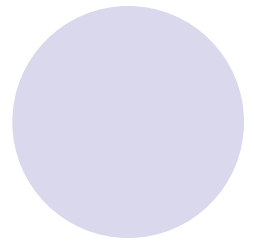
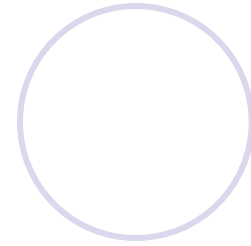
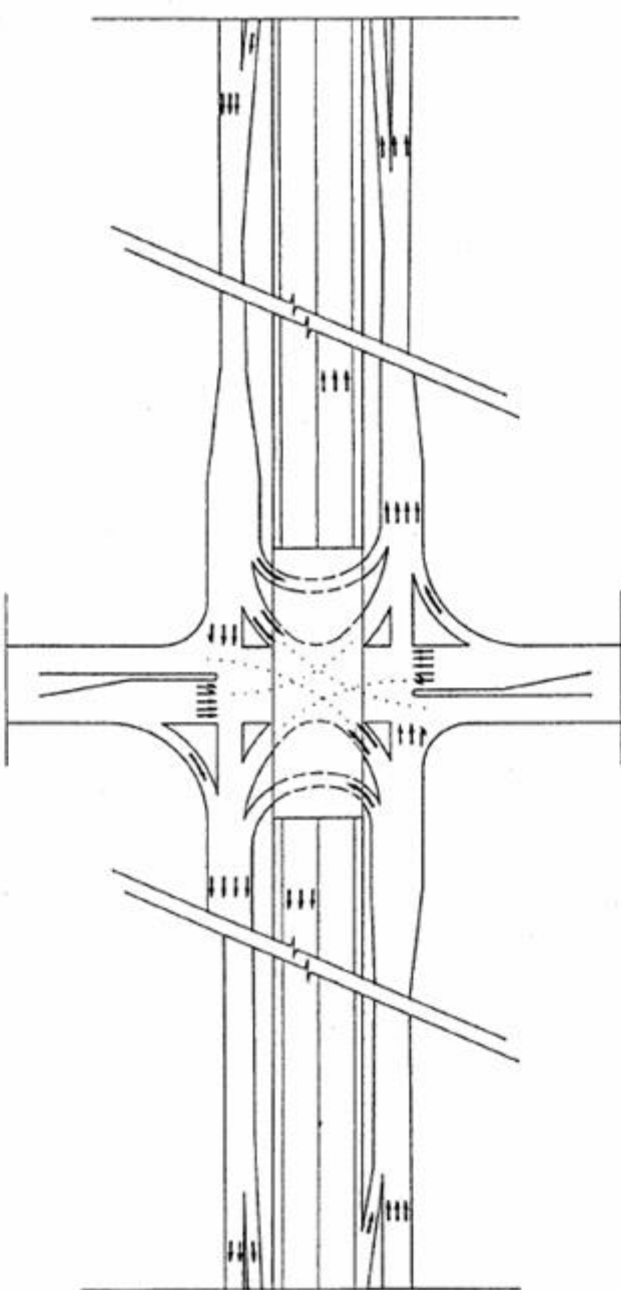
http://www.thenewi64.org/1c4_spui.jsp₃₄



http://www.thenewi64.org/1c4_spui35jsp



Source: Stanley Consultants, Inc. 36



Overpass SPUI

Long span, regular deck



http://www.thenewi64.org/1c4_spui38.jsp

Advantages of SPUI

- All 4 LT movements controlled by single traffic signal
- RT are freeflow movements
- Good with narrow ROW
- Higher capacity

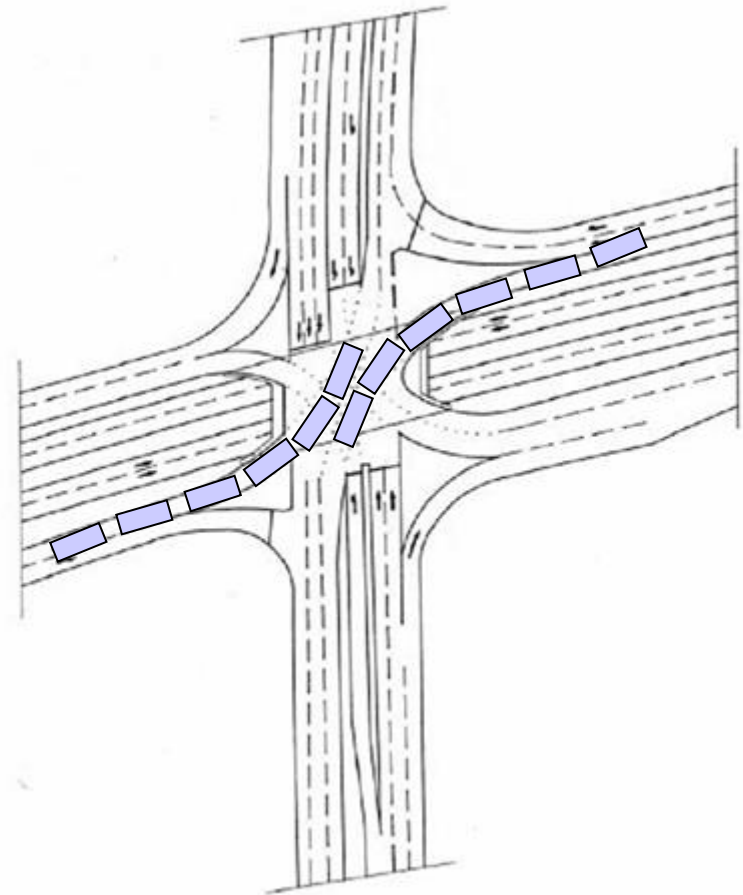


Exhibit 10-23. An SPUI Underpass in Restricted Right-of-Way

Disadvantages of SPUI

- High construction **costs**
- Difficult for **pedestrians** to negotiate
- **Complex** intersection and signal phases may be **unfamiliar** to drivers
- Multilane ramps or surface streets can lead to very large areas of **uncontrolled pavement** (used by vehicles in more than one direction)
- Distance between stop bars on surface street creates problems for **bicycles**, who need more time to clear the area between them
- More free-flow motor vehicle movements (part of what increases the SPUI's capacity) makes it harder for **pedestrians** to safely cross
- The standard traffic signal timing does not include a **phase for pedestrian** crossing; again, capacity and safety are at odds
- Vehicle **clearance** time (where all lights must be red) is longer
- **Longer or wider overpasses** can require larger bridge girders; retrofits can require raising the bridge or lowering the road underneath

Directional/Semi-Directional

- Apply: freeway to freeway or other intersecting roadways with major turning movements (where diamond, cloverleaf or SPUI can't handle the volumes)
- Allows higher LOS
- Advantages over cloverleaf
 - Higher speed left turn
 - less weaving (often none)
 - normal exit/entrance patterns

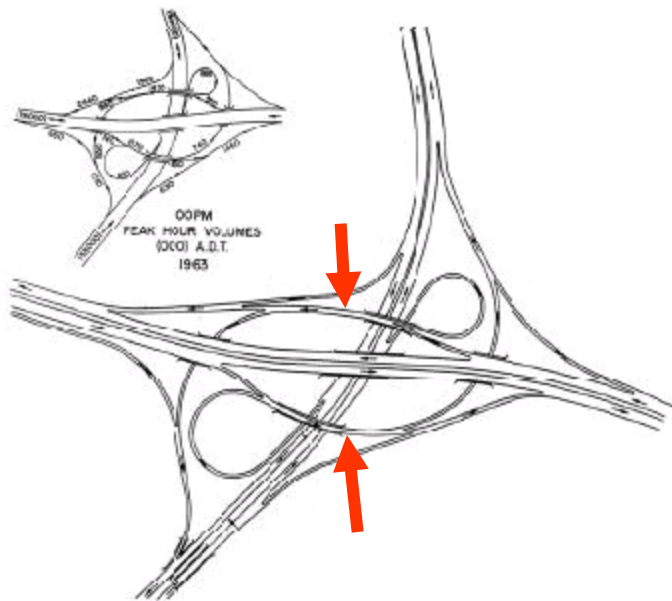


Exhibit 10-34. Directional Interchange, Two Semidirect Connections



Exhibit 10-35. Four-Level Directional Interchange

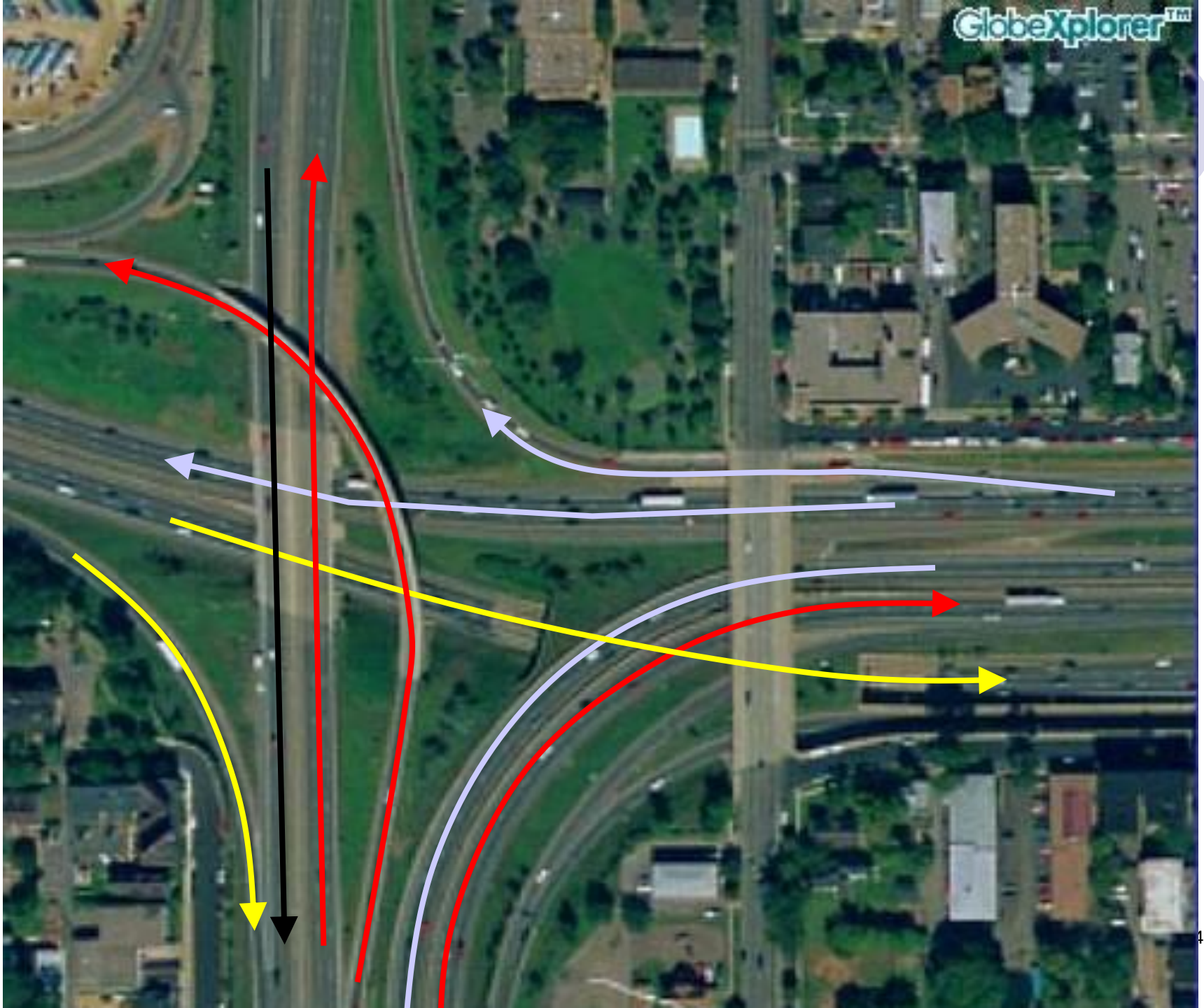


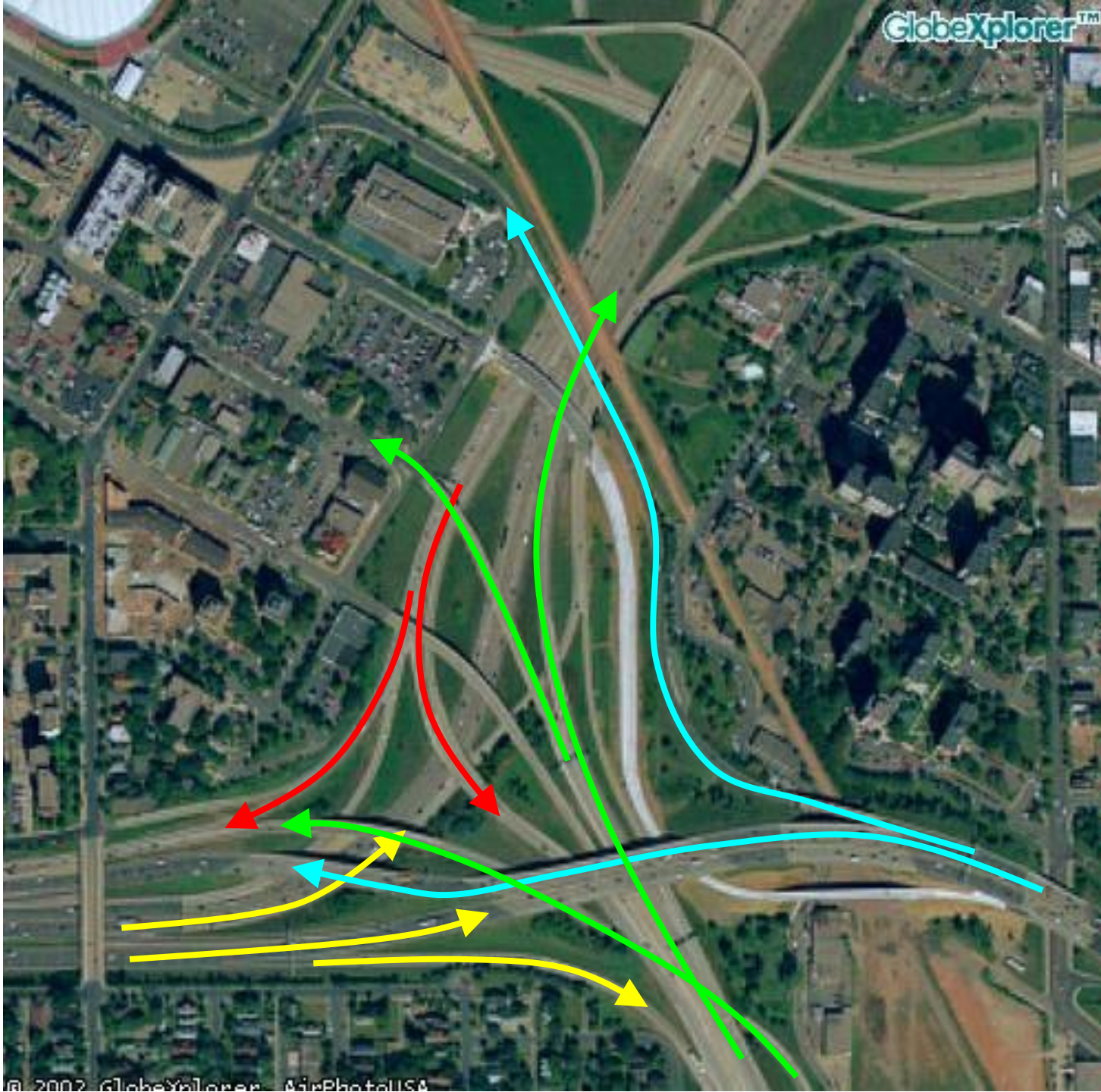
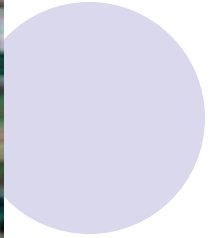
Exhibit 10-36. Four-Level Directional Interchange



Exhibit 10-37. Semidirectional Interchange With Loops







Characteristics/Comparison of Basic Interchange Types

	Diamond	Cloverleaf	Directional
Ramp Types	Diagonal	Loop or diagonal	Semidirectional, or directional
Left	Diagonal	Outer connection or diagonal	Outer connection
Right			
Structures	1 (typical)	1	Multiple
Levels	2 (typical)	2	≥ 3
ROW	Relatively small	Moderate	Relatively large
Construction Cost	Relatively small	Moderate	Relatively large
Convenience of Left Turn Movement	Adv: Shortest path Dis: Cross-street junction at grade	Adv: Acute angle merges at both junctions Dis: Path is indirect, long, and low speed	Adv: High speed path, acute angle merges at both junctions Dis: Path is long
Pattern of Entrance and Exits	Normal pattern of exit before, entrance after cross street; no weaving	Abnormal pattern with entrance before, exit after cross street; weaving between entrance and exit	Normal exit before, enter after cross street; no weaving

Alternatives

Diamond



Diamond with a Loop



Tight Diamond



Alternatives

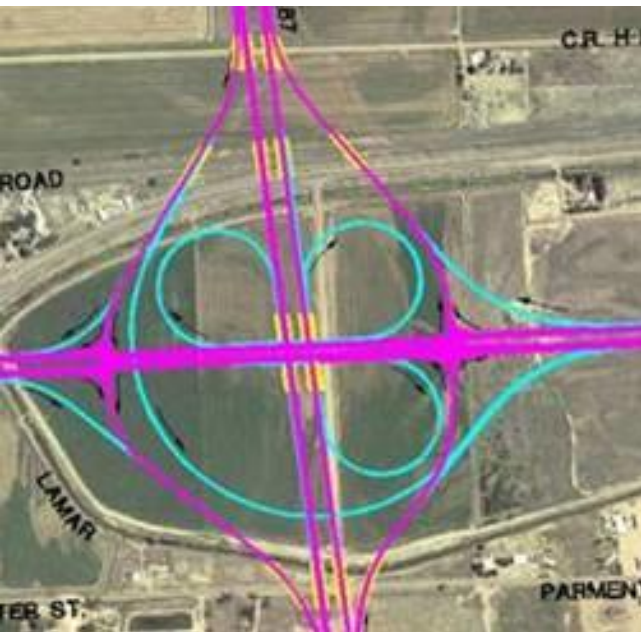
Diamond



Diamond with Flyover



Loop with Flyover



Alternatives

Partial Cloverleaf
(Shifted North)



Northbound Right Exit



Folded Diamond



Partial Cloverleaf (ParClo)



Northbound Left Exit



Half Diamond

